DATS 6103 - Individual Project 2 - Joseph Valle

November 8, 2020

1 An Economic Analysis of Virginia from 2001 to 2018

1.0.1 DATS 6103 - Fall 2020 - Joseph Valle

1.1 1. Introduction

As the US's economy continues to evolve with the rapid tide of globalization and interstate commerce, the opportunities for growth and development for businesses among a variety of sectors have likewise expanded notably over the last two decades. One state that has especially drawn attention as of late for its economic potence is Virginia, partly on account of its proximity to Washington, DC, as well as the nationwide shift toward more technological jobs.

This project will interpret the trends in population, income, and GDP by industry throughout Virginia from 2001 to 2018. Rather than analyze Virginia as a whole, we can delve further and examine its individual geographic areas. As a reference over the course of this project, a geographic area can be defined as a county or independent city within Virginia. We do this in order to take into account the impact of geography on predominant industries. Of course, we can also consider how the rise of an industry in a certain area can affect said area's population and income over time.

Our data can be found at the Bureau of Economic Analysis, and downloaded and converted as CSV files with the help of Pandas. After cleaning up our data to focus on the years 2001 through 2018, we will first look at trends in personal and per capita income in both absolute and relative figures. Similarly, we will pivot toward population, and isolate the areas with the most significant absolute and relative shifts in this regard. Finally, we will expand our inquiry toward identifying which areas contributed the most in terms of GDP and share of GDP for a given industry. As an extension to this last point, we will also determine the most significant sectors for a given area, and based on their share values evaluate whether or not that area reported a diversified economy, or relied disproportionately on one particular sector. With this in mind, we can deduce if there are any industries drawing more people toward certain areas.

Any references that were helpful in completing this project are listed at the bottom of this Jupyter Notebook.

1.2 2. Installing Our Data

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.ticker as mtick
import seaborn as sb
import warnings
warnings.filterwarnings('ignore')
```

[2]:
```
pop_inc = pd.read_csv("pop_inc.csv")
ind_gdp = pd.read_csv("ind_gdp.csv")

#Respectively, our data sets consist of figures with regard to population and␣
 ↪income, and GDP by industry.
```

[3]:
```
pop_inc.head()
```

[3]:
```
   GeoFIPS        GeoName Region TableName  LineCode IndustryClassification  \
0  "00000"  United States           CAINC1       1.0                     …
1  "00000"  United States           CAINC1       2.0                     …
2  "00000"  United States           CAINC1       3.0                     …
3  "01000"        Alabama      5    CAINC1       1.0                     …
4  "01000"        Alabama      5    CAINC1       2.0                     …

                               Description                  Unit       1969  \
0   Personal income (thousands of dollars)  Thousands of dollars  791229000
1                  Population (persons) 1/     Number of persons  201298000
2  Per capita personal income (dollars) 2/               Dollars       3931
3   Personal income (thousands of dollars)  Thousands of dollars    9737715
4                  Population (persons) 1/     Number of persons    3440000

         1970  …         2009         2010         2011         2012  \
0  855525000  …  12051307000  12541995000  13315478000  13998383000
1  203798722  …    306771529    309326085    311580009    313874218
2       4198  …        39284        40546        42735        44599
3   10628318  …    155145273    161516561    167942757    172804075
4    3449846  …      4757938      4785448      4798834      4815564

          2013         2014         2015         2016         2017  \
0  14175503000  14982715000  15709242000  16111636000  16870106000
1    316057727    318386421    320742673    323071342    325147121
2        44851        47058        48978        49870        51885
3    174415510    180457769    187544435    190814674    197283188
4      4830460      4842481      4853160      4864745      4875120

          2018
0  17813035000
1    327167434
2        54446
3    206455011
4      4887871

[5 rows x 58 columns]
```

[4]:

```
ind_gdp.head()
```

[4]:

```
   GeoFIPS          GeoName Region TableName  LineCode IndustryClassification  \
0  "00000"  United States *           CAGDP2       1.0                      …
1  "00000"  United States *           CAGDP2       2.0                      …
2  "00000"  United States *           CAGDP2       3.0                     11
3  "00000"  United States *           CAGDP2       6.0                     21
4  "00000"  United States *           CAGDP2      10.0                     22

                                       Description                  Unit  \
0                                All industry total  Thousands of dollars
1                                Private industries  Thousands of dollars
2        Agriculture, forestry, fishing and hunting  Thousands of dollars
3     Mining, quarrying, and oil and gas extraction  Thousands of dollars
4                                         Utilities  Thousands of dollars

          2001         2002  …         2009         2010         2011  \
0  10581822000  10936418000  …  14448932000  14992052000  15542582000
1   9188887407   9462019658  …  12403879944  12884088643  13405519970
2     99835618     95628974  …    129967839    146299048    180944850
3    123924346    112417015  …    275840872    305838102    356315451
4    181332474    177617765  …    258241011    278837008    287459067

          2012         2013         2014         2015         2016  \
0  16197007000  16784851000  17527258000  18224780000  18715040000
1  14037519000  14572341002  15255889000  15883937000  16326092000
2    179573000    215600643    201003000    180655000    164281000
3    358798000    386518621    416375000    259863000    215621000
4    279651000    286340248    298076000    299214000    302355000

          2017         2018
0  19519424000  20580223000
1  17065802000  18035586000
2    174579000    166464000
3    287324000    346645000
4    315114000    325852000

[5 rows x 26 columns]
```

[5]:

```
print(pop_inc.shape)
print(ind_gdp.shape)
```

```
(9597, 58)
(107988, 26)
```

[6]:

```
pop_inc = pop_inc[pop_inc['GeoName'].str.contains('VA', na=False)]
ind_gdp = ind_gdp[ind_gdp['GeoName'].str.contains('VA', na=False)]
```

```
pop_inc = pop_inc.iloc[:,np.r_[1,6,7,40:58]]
ind_gdp = ind_gdp.iloc[:,np.r_[1,6:26]]

#Upon inspecting both data sets at first glance, we notice that we can study␣
 ↪the years 2001 through 2018 in each for
#the duration of our project.  We also make sure to include the columns␣
 ↪indicating the names of geographic areas
#(defined as counties and independent cities for this project), descriptions of␣
 ↪variables to study, and units for
#these variables.  Recall that figures pertaining to the whole state of␣
 ↪Virginia are not included.
```

1.3 3. Cleaning Up Our Data

Before we can analyze the economic trends characterizing Virginia's counties and independent cities, we need to take several more steps toward cleaning up our data. In particular, upon observing both data sets, we notice that the Bureau of Economic Analysis has occasionally consolidated one or more cities under an adjacent county's name for statistical purposes. As a note for later visualizations, some counties may report higher figures for population, income, and GDP because they also incorporated a number of cities within their definitions. As an example, Fairfax County included under its description Fairfax City and Falls Church, despite these two being independent. This should not be conflated with any cities that already present their own separate figures, such as Alexandria and Virginia Beach.

Additionally, from our GDP by industry data set, we notice that some areas did not report any figures for certain industries, regardless of the year. To resolve this, we can isolate our industries of interest by consolidating some under one description for simplicity purposes. For instance, we can analyze the trade industry without having to inspect wholesale and retail trade in separate descriptions. In doing so, we can add the individual industries together to obtain the total GDP values for each area from 2001 to 2018, and avoid reporting aggregate figures that may not account for certain sectors. This latter observation will be especially important in the final section of our project.

[7]:

```
list(pop_inc.GeoName.unique())

#Note that some counties have neighboring independent cities (cities not␣
 ↪enclosed within any county) attached to their
#name by the Bureau of Economic Analysis, our original data's source, for␣
 ↪statistical purposes.
```

[7]:

```
['Accomack, VA',
 'Amelia, VA',
 'Amherst, VA',
 'Appomattox, VA',
 'Arlington, VA',
 'Bath, VA',
 'Bedford, VA*',
 'Bland, VA',
 'Botetourt, VA',
 'Brunswick, VA',
 'Buchanan, VA',
 'Buckingham, VA',
 'Caroline, VA',
 'Charles City, VA',
 'Charlotte, VA',
 'Chesterfield, VA',
 'Clarke, VA',
 'Craig, VA',
 'Culpeper, VA',
 'Cumberland, VA',
 'Dickenson, VA',
 'Essex, VA',
 'Fauquier, VA',
 'Floyd, VA',
 'Fluvanna, VA',
 'Franklin, VA',
 'Giles, VA',
 'Gloucester, VA',
 'Goochland, VA',
 'Grayson, VA',
 'Greene, VA',
 'Halifax, VA',
 'Hanover, VA',
 'Henrico, VA',
 'Highland, VA',
 'Isle of Wight, VA',
 'King and Queen, VA',
 'King George, VA',
 'King William, VA',
 'Lancaster, VA',
 'Lee, VA',
 'Loudoun, VA',
 'Louisa, VA',
 'Lunenburg, VA',
 'Madison, VA',
 'Mathews, VA',
 'Mecklenburg, VA',
 'Middlesex, VA',
 'Nelson, VA',
 'New Kent, VA',
 'Northampton, VA',
 'Northumberland, VA',
 'Nottoway, VA',
 'Orange, VA',
 'Page, VA',
 'Patrick, VA',
 'Powhatan, VA',
 'Prince Edward, VA',
 'Pulaski, VA',
 'Rappahannock, VA',
 'Richmond, VA',
 'Russell, VA',
 'Scott, VA',
 'Shenandoah, VA',
 'Smyth, VA',
 'Stafford, VA',
 'Surry, VA',
 'Sussex, VA',
 'Tazewell, VA',
 'Warren, VA',
 'Westmoreland, VA',
 'Wythe, VA',
 'Alexandria (Independent City), VA',
 'Chesapeake (Independent City), VA',
 'Hampton (Independent City), VA',
 'Newport News (Independent City), VA',
 'Norfolk (Independent City), VA',
 'Portsmouth (Independent City), VA',
 'Richmond (Independent City), VA',
 'Roanoke (Independent City), VA',
 'Suffolk (Independent City), VA',
 'Virginia Beach (Independent City), VA',
 'Albemarle + Charlottesville, VA*',
 'Alleghany + Covington, VA*',
 'Augusta, Staunton + Waynesboro, VA*',
 'Campbell + Lynchburg, VA*',
 'Carroll + Galax, VA*',
 'Dinwiddie, Colonial Heights + Petersburg, VA*',
 'Fairfax, Fairfax City + Falls Church, VA*',
 'Frederick + Winchester, VA*',
 'Greensville + Emporia, VA*',
 'Henry + Martinsville, VA*',
 'James City + Williamsburg, VA*',
 'Montgomery + Radford, VA*',
 'Pittsylvania + Danville, VA*',
 'Prince George + Hopewell, VA*',
 'Prince William, Manassas + Manassas Park, VA*',
 'Roanoke + Salem, VA*',
 'Rockbridge, Buena Vista + Lexington, VA*',
 'Rockingham + Harrisonburg, VA*',
 'Southampton + Franklin, VA*',
 'Spotsylvania + Fredericksburg, VA*',
 'Washington + Bristol, VA*',
 'Wise + Norton, VA*',
 'York + Poquoson, VA*']
```

[8]:

```
pop_inc = pop_inc.replace('Bedford, VA*','Bedford, VA')
ind_gdp = ind_gdp.replace('Bedford, VA*','Bedford, VA')

#We remove the asterisk next to Bedford County's name for convenience.
```

[9]:

```
pop_inc = pop_inc.replace('Albemarle + Charlottesville, VA*','Albemarle, VA')
pop_inc = pop_inc.replace('Alleghany + Covington, VA*','Alleghany, VA')
pop_inc = pop_inc.replace('Augusta, Staunton + Waynesboro, VA*','Augusta, VA')
pop_inc = pop_inc.replace('Campbell + Lynchburg, VA*','Campbell, VA')
pop_inc = pop_inc.replace('Carroll + Galax, VA*','Carroll, VA')
pop_inc = pop_inc.replace('Dinwiddie, Colonial Heights + Petersburg,␣
 ↪VA*','Dinwiddie, VA')
pop_inc = pop_inc.replace('Fairfax, Fairfax City + Falls Church, VA*','Fairfax,␣
 ↪VA')
pop_inc = pop_inc.replace('Frederick + Winchester, VA*','Frederick, VA')
pop_inc = pop_inc.replace('Greensville + Emporia, VA*','Greensville, VA')
pop_inc = pop_inc.replace('Henry + Martinsville, VA*','Henry, VA')
pop_inc = pop_inc.replace('James City + Williamsburg, VA*','James City, VA')
pop_inc = pop_inc.replace('Montgomery + Radford, VA*','Montgomery, VA')
pop_inc = pop_inc.replace('Pittsylvania + Danville, VA*','Pittsylvania, VA')
pop_inc = pop_inc.replace('Prince George + Hopewell, VA*','Prince George, VA')
pop_inc = pop_inc.replace('Prince William, Manassas + Manassas Park,␣
 ↪VA*','Prince William, VA')
pop_inc = pop_inc.replace('Roanoke + Salem, VA*','Roanoke, VA')
pop_inc = pop_inc.replace('Rockbridge, Buena Vista + Lexington,␣
 ↪VA*','Rockbridge, VA')
pop_inc = pop_inc.replace('Rockingham + Harrisonburg, VA*','Rockingham, VA')
pop_inc = pop_inc.replace('Southampton + Franklin, VA*','Southampton, VA')
pop_inc = pop_inc.replace('Spotsylvania + Fredericksburg, VA*','Spotsylvania,␣
 ↪VA')
pop_inc = pop_inc.replace('Washington + Bristol, VA*','Washington, VA')
pop_inc = pop_inc.replace('Wise + Norton, VA*','Wise, VA')
pop_inc = pop_inc.replace('York + Poquoson, VA*','York, VA')

#For simplicity purposes, we rename the counties with neighboring independent␣
 ↪cities with only the county name in our
#population and income data set.
```

[10]:

```
ind_gdp = ind_gdp.replace('Albemarle + Charlottesville, VA*','Albemarle, VA')
ind_gdp = ind_gdp.replace('Alleghany + Covington, VA*','Alleghany, VA')
ind_gdp = ind_gdp.replace('Augusta, Staunton + Waynesboro, VA*','Augusta, VA')
ind_gdp = ind_gdp.replace('Campbell + Lynchburg, VA*','Campbell, VA')
ind_gdp = ind_gdp.replace('Carroll + Galax, VA*','Carroll, VA')
ind_gdp = ind_gdp.replace('Dinwiddie, Colonial Heights + Petersburg,␣
 ↪VA*','Dinwiddie, VA')
ind_gdp = ind_gdp.replace('Fairfax, Fairfax City + Falls Church, VA*','Fairfax,␣
 ↪VA')
ind_gdp = ind_gdp.replace('Frederick + Winchester, VA*','Frederick, VA')
ind_gdp = ind_gdp.replace('Greensville + Emporia, VA*','Greensville, VA')
ind_gdp = ind_gdp.replace('Henry + Martinsville, VA*','Henry, VA')
ind_gdp = ind_gdp.replace('James City + Williamsburg, VA*','James City, VA')
ind_gdp = ind_gdp.replace('Montgomery + Radford, VA*','Montgomery, VA')
ind_gdp = ind_gdp.replace('Pittsylvania + Danville, VA*','Pittsylvania, VA')
ind_gdp = ind_gdp.replace('Prince George + Hopewell, VA*','Prince George, VA')
ind_gdp = ind_gdp.replace('Prince William, Manassas + Manassas Park,␣
 ↪VA*','Prince William, VA')
ind_gdp = ind_gdp.replace('Roanoke + Salem, VA*','Roanoke, VA')
ind_gdp = ind_gdp.replace('Rockbridge, Buena Vista + Lexington,␣
 ↪VA*','Rockbridge, VA')
ind_gdp = ind_gdp.replace('Rockingham + Harrisonburg, VA*','Rockingham, VA')
ind_gdp = ind_gdp.replace('Southampton + Franklin, VA*','Southampton, VA')
ind_gdp = ind_gdp.replace('Spotsylvania + Fredericksburg, VA*','Spotsylvania,␣
 ↪VA')
ind_gdp = ind_gdp.replace('Washington + Bristol, VA*','Washington, VA')
ind_gdp = ind_gdp.replace('Wise + Norton, VA*','Wise, VA')
ind_gdp = ind_gdp.replace('York + Poquoson, VA*','York, VA')

#We also do this for our GDP by industry data set.
```

```
[11]: pop_inc = pop_inc.sort_values(by='GeoName')
ind_gdp = ind_gdp.sort_values(by='GeoName')

#We sort the cities and counties in alphabetical order in both data sets.
```

```
[12]: list(ind_gdp.Description.unique())
```

```
[12]: ['All industry total',
 '   Administrative and support and waste management and remediation services',
 '  Educational services, health care, and social assistance',
 '   Educational services',
 '   Health care and social assistance',
 '  Arts, entertainment, recreation, accommodation, and food services',
 '   Arts, entertainment, and recreation',
 '   Management of companies and enterprises',
 '   Accommodation and food services',
 'Government and government enterprises',
 'Natural resources and mining',
 'Trade',
 'Transportation and utilities',
 'Manufacturing and information',
 'Private goods-producing industries 2/',
 '  Other services (except government and government enterprises)',
 '   Professional, scientific, and technical services',
 'Private services-providing industries 3/',
 '   Real estate and rental and leasing',
 ' Private industries',
 '  Agriculture, forestry, fishing and hunting',
 '  Mining, quarrying, and oil and gas extraction',
 '  Utilities',
 '  Professional and business services',
 '  Manufacturing',
 '   Durable goods manufacturing',
 '  Construction',
 '  Wholesale trade',
 '  Retail trade',
 '  Transportation and warehousing',
 '  Information',
 '  Finance, insurance, real estate, rental, and leasing',
 '   Finance and insurance',
 '   Nondurable goods manufacturing']
```

[13]:
```
ind_gdp = ind_gdp[(ind_gdp.Description == '  Utilities')|
                  (ind_gdp.Description == '  Construction')|
                  (ind_gdp.Description == '  Manufacturing')|
                  (ind_gdp.Description == '  Transportation and warehousing')|
                  (ind_gdp.Description == '  Information')|
                  (ind_gdp.Description == '  Finance, insurance, real estate,␣
 ↪rental, and leasing')|
                  (ind_gdp.Description == '  Professional and business␣
 ↪services')|
                  (ind_gdp.Description == '  Educational services, health care,␣
 ↪and social assistance')|
                  (ind_gdp.Description == '  Arts, entertainment, recreation,␣
 ↪accommodation, and food services')|
                  (ind_gdp.Description == '  Other services (except government␣
 ↪and government enterprises)')|
                  (ind_gdp.Description == 'Government and government␣
 ↪enterprises')|
                  (ind_gdp.Description == 'Natural resources and mining')|
                  (ind_gdp.Description == 'Trade')]

#We select the industries that jointly form the whole of each area's GDP.
```

[14]:
```
list(pop_inc.Description.unique())
```

```
[14]: ['Personal income (thousands of dollars)',
       'Population (persons) 1/',
       'Per capita personal income (dollars) 2/']
```

```
[15]: pop_inc = pop_inc.replace('Personal income (thousands of dollars)','Personal␣
       ↪income')
      pop_inc = pop_inc.replace('Population (persons) 1/','Population')
      pop_inc = pop_inc.replace('Per capita personal income (dollars) 2/','Per capita␣
       ↪personal income')
      pop_inc.head()

      #We rename each of the descriptions in our population and income data set for␣
       ↪our convenience.
```

```
[15]:             GeoName                 Description                  Unit  \
      8673   Accomack, VA             Personal income  Thousands of dollars
      8674   Accomack, VA                  Population     Number of persons
      8675   Accomack, VA  Per capita personal income               Dollars
      8919  Albemarle, VA             Personal income  Thousands of dollars
      8920  Albemarle, VA                  Population     Number of persons

               2001     2002     2003     2004     2005     2006     2007  …  \
      8673   798158   827094   881556   921178   955300   979101  1033169  …
      8674    37742    37308    36742    36310    35835    35192    34553  …
      8675    21148    22169    23993    25370    26658    27822    29901  …
      8919  4673545  4769895  5104606  5459814  5877106  6463224  6897809  …
      8920   126438   127599   128315   129772   132273   134918   136547  …

               2009     2010     2011     2012     2013     2014     2015      2016  \
      8673  1092338  1114647  1131424  1185059  1192333  1234064  1281707   1288081
      8674    33415    33147    33221    33264    32966    32970    32910     32850
      8675    32690    33627    34057    35626    36169    37430    38946     39211
      8919  6859572  7240429  7657164  8457472  8328130  8935308  9550724  10091356
      8920   141125   142659   143960   146043   147286   149265   151552    153644

                2017      2018
      8673   1325930   1386063
      8674     32566     32412
      8675     40715     42764
      8919  11027861  11702008
      8920    155690    156835

      [5 rows x 21 columns]
```

```
[16]: ind_gdp = ind_gdp.replace('  Utilities','Utilities')
      ind_gdp = ind_gdp.replace('  Construction','Construction')
      ind_gdp = ind_gdp.replace('  Manufacturing','Manufacturing')
      ind_gdp = ind_gdp.replace('  Transportation and warehousing','Transportation␣
       ↪and warehousing')
      ind_gdp = ind_gdp.replace('  Information','Information')
      ind_gdp = ind_gdp.replace('  Finance, insurance, real estate, rental, and␣
       ↪leasing',
                        'Finance, insurance, real estate, rental, and leasing')
      ind_gdp = ind_gdp.replace('  Professional and business services','Professional␣
       ↪and business services')
      ind_gdp = ind_gdp.replace('  Educational services, health care, and social␣
       ↪assistance',
                        'Educational services, health care, and social assistance')
      ind_gdp = ind_gdp.replace('  Arts, entertainment, recreation, accommodation,␣
       ↪and food services',
                        'Arts, entertainment, recreation, accommodation, and food␣
       ↪services')
      ind_gdp = ind_gdp.replace('  Other services (except government and government␣
       ↪enterprises)',
                        'Other services (except government and government␣
       ↪enterprises)')
      ind_gdp.iloc[:13]

      #Similarly as with our population and income data set, we clean up the␣
       ↪descriptions in our GDP by industry data set by
      #removing any unnecessary spaces.
```

```
[16]:            GeoName                                          Description  \
      97600  Accomack, VA  Educational services, health care, and social …
      97603  Accomack, VA  Arts, entertainment, recreation, accommodation…
      97607  Accomack, VA              Government and government enterprises
      97608  Accomack, VA                       Natural resources and mining
      97609  Accomack, VA                                              Trade
      97606  Accomack, VA  Other services (except government and governme…
      97584  Accomack, VA                                          Utilities
      97596  Accomack, VA                 Professional and business services
      97586  Accomack, VA                                      Manufacturing
      97585  Accomack, VA                                       Construction
      97591  Accomack, VA                     Transportation and warehousing
      97592  Accomack, VA                                        Information
      97593  Accomack, VA  Finance, insurance, real estate, rental, and l…

                         Unit    2001    2002    2003    2004    2005    2006  \
      97600  Thousands of dollars   27223   28647   32077   37547   41549   42389
      97603  Thousands of dollars   34126   37456   39080   39118   38107   37866
      97607  Thousands of dollars  156465  167679  175405  184208  192721  197611
      97608  Thousands of dollars   83645   65085   88560  133653  134892  130349
      97609  Thousands of dollars   76146   79415   85706   82571     (D)   89493
```

```
97606  Thousands of dollars   23772   25855   27864   29623   29898   30268
97584  Thousands of dollars    5866   10268   14620   12140     (D)    8216
97596  Thousands of dollars   56653   65408   71020   84238   95110   97100
97586  Thousands of dollars  813624  694819  621442  565466  534804  582652
97585  Thousands of dollars   29243   34470   35598   41966   42699   46380
97591  Thousands of dollars   11738   11791   11112   10361    9615    9953
97592  Thousands of dollars   15629   23334   21770   13190   11943   10707
97593  Thousands of dollars  143678  150373  164952  158824  181453  225503

         2007  …     2009     2010     2011     2012     2013     2014  \
97600   41554  …    50434    48325    46856    50557      (D)      (D)
97603   39701  …    38456    39535    41137    44429    45583    47178
97607  203717  …   218814   225499   223419   229542   234298   247339
97608  119118  …   113148   108568   118920   103134   138035   118326
97609   86126  …    85528    89499    96774   100664   109832   110322
97606   29452  …    28465    28217    27913    28727    28233    29084
97584    8129  …     9843    12892    11826    14373    12593    20990
97596  102973  …   115628   124464   113227   133154   135050   132552
97586  568388  …  1201961  1362066  1330363  1441586  1510046  1565767
97585   44505  …    41002    41771    37284    45787    40722    36705
97591    9410  …     8136    10316    12152    15499      (D)      (D)
97592   12199  …    13320    13023    11075     9689    10166     9991
97593  242451  …   236876   232431   241862   243938   245562   251988

          2015     2016     2017     2018
97600      (D)      (D)      (D)      (D)
97603    47772    49971    51275    53617
97607   254782   258345   267064   273468
97608   102373    85647    97286    88750
97609   113873   115564   116106   120973
97606    30137    29309    30166    31614
97584    19480    18410    25643    28675
97596   141455   140972   138905   152281
97586  1752051  1802328  1804397  1852963
97585    51381    55549    42424    40633
97591      (D)      (D)      (D)      (D)
97592    10189    10822    10962    10824
97593   256643   263338   266813   278947

[13 rows x 21 columns]
```

[17]:
```
ind_gdp = ind_gdp.replace('(D)',0) #We replace any 'D' values with zeros to␣
 ↪maintain consistency.
ind_gdp.head()
```

[17]:
```
            GeoName                                        Description  \
97600  Accomack, VA  Educational services, health care, and social …
```

```
97603  Accomack, VA  Arts, entertainment, recreation, accommodation…
97607  Accomack, VA             Government and government enterprises
97608  Accomack, VA                      Natural resources and mining
97609  Accomack, VA                                             Trade

                       Unit    2001    2002    2003    2004    2005    2006  \
97600  Thousands of dollars   27223   28647   32077   37547   41549   42389
97603  Thousands of dollars   34126   37456   39080   39118   38107   37866
97607  Thousands of dollars  156465  167679  175405  184208  192721  197611
97608  Thousands of dollars   83645   65085   88560  133653  134892  130349
97609  Thousands of dollars   76146   79415   85706   82571       0   89493

         2007  …    2009    2010    2011    2012    2013    2014    2015  \
97600   41554  …   50434   48325   46856   50557       0       0       0
97603   39701  …   38456   39535   41137   44429   45583   47178   47772
97607  203717  …  218814  225499  223419  229542  234298  247339  254782
97608  119118  …  113148  108568  118920  103134  138035  118326  102373
97609   86126  …   85528   89499   96774  100664  109832  110322  113873

         2016    2017    2018
97600       0       0       0
97603   49971   51275   53617
97607  258345  267064  273468
97608   85647   97286   88750
97609  115564  116106  120973

[5 rows x 21 columns]
```

```
[18]: pop_inc = pop_inc.sort_values(by='GeoName') #We sort the areas in alphabetical␣
       ↪order for both data sets.
      ind_gdp = ind_gdp.sort_values(by='GeoName')
```

```
[19]: pop_inc.dtypes #This is to ensure that we are working with floats so we can␣
       ↪visualize our data later.
```

```
[19]: GeoName        object
      Description    object
      Unit           object
      2001           object
      2002           object
      2003           object
      2004           object
      2005           object
      2006           object
      2007           object
      2008           object
      2009           object
```

```
2010           object
2011           object
2012           object
2013           object
2014           object
2015           object
2016           object
2017           object
2018           object
dtype: object
```

[20]:

```
ind_gdp.dtypes
```

[20]:

```
GeoName        object
Description    object
Unit           object
2001           object
2002           object
2003           object
2004           object
2005           object
2006           object
2007           object
2008           object
2009           object
2010           object
2011           object
2012           object
2013           object
2014           object
2015           object
2016           object
2017           object
2018           object
dtype: object
```

[21]:

```
pop_inc = pop_inc.apply(pd.to_numeric, errors='ignore', downcast='float')
ind_gdp = ind_gdp.apply(pd.to_numeric, errors='ignore', downcast='float')
pop_inc = pop_inc.set_index('GeoName')
ind_gdp = ind_gdp.set_index('GeoName')
print(pop_inc.shape)
print(ind_gdp.shape)

#After converting the numeric (year) columns to floats, we can establish our␣
 ↪index as GeoName.
```

```
(315, 20)
```

```
(1365, 20)
```

[22]:

```
sb.set(rc={'figure.figsize':(10,5)}) #We assign a default figure size for our␣
↪visualizations.
```

1.4 4. Evaluating Trends in Income

[23]:

```
total_inc = pop_inc[(pop_inc.Description == 'Personal income')]
total_inc['01-18 Ab Inc'] = total_inc['2018']-total_inc['2001']
total_inc['01-18 Pct Inc'] = (total_inc['2018']-total_inc['2001'])/
↪total_inc['2001']*100
total_inc = total_inc.iloc[:,np.r_[0,2:22]]
total_inc.head()

#We calculate the absolute and relative changes in personal income (total␣
↪income over the whole population) throughout
#Virginia from 2001 to 2018.
```

[23]:

```
                                        Description       2001       2002  \
GeoName
Accomack, VA                        Personal income   798158.0   827094.0
Albemarle, VA                       Personal income  4673545.0  4769895.0
Alexandria (Independent City), VA   Personal income  6970776.0  7044342.0
Alleghany, VA                       Personal income   556362.0   566680.0
Amelia, VA                          Personal income   291481.0   291610.0

                                         2003       2004       2005       2006  \
GeoName
Accomack, VA                         881556.0   921178.0   955300.0   979101.0
Albemarle, VA                       5104606.0  5459814.0  5877106.0  6463224.0
Alexandria (Independent City), VA   7308409.0  7945125.0  8480858.0  9067312.0
Alleghany, VA                        588800.0   603056.0   618782.0   638739.0
Amelia, VA                           304391.0   339501.0   362798.0   386528.0

                                         2007       2008       2009  …  \
GeoName                                                              …
Accomack, VA                        1033169.0  1089135.0  1092338.0  …
Albemarle, VA                       6897809.0  7167152.0  6859572.0  …
Alexandria (Independent City), VA   9318719.0  9954991.0  9963806.0  …
Alleghany, VA                        656422.0   707451.0   689865.0  …
Amelia, VA                           416917.0   418772.0   404473.0  …

                                          2011        2012        2013  \
GeoName
Accomack, VA                         1131424.0   1185059.0   1192333.0
Albemarle, VA                        7657164.0   8457472.0   8328130.0
Alexandria (Independent City), VA   11424532.0  12143013.0  11711094.0
```

```
Alleghany, VA                        724411.0    767944.0    720625.0
Amelia, VA                           437706.0    460323.0    494560.0

                                         2014        2015        2016  \
GeoName
Accomack, VA                        1234064.0   1281707.0   1288081.0
Albemarle, VA                       8935308.0   9550724.0  10091356.0
Alexandria (Independent City), VA  12316722.0  12749013.0  13027528.0
Alleghany, VA                        738863.0    771583.0    774653.0
Amelia, VA                           511085.0    539074.0    542679.0

                                         2017        2018  01-18 Ab Inc  \
GeoName
Accomack, VA                        1325930.0   1386063.0      587905.0
Albemarle, VA                      11027861.0  11702008.0     7028463.0
Alexandria (Independent City), VA  13420320.0  14127927.0     7157151.0
Alleghany, VA                        785845.0    816049.0      259687.0
Amelia, VA                           558329.0    582640.0      291159.0

                                   01-18 Pct Inc
GeoName
Accomack, VA                           73.657722
Albemarle, VA                         150.388260
Alexandria (Independent City), VA     102.673660
Alleghany, VA                          46.675907
Amelia, VA                             99.889526

[5 rows x 21 columns]
```

[24]:

```
total_inc['2001'] = total_inc['2001']*1000/(10**9)
total_inc['2002'] = total_inc['2002']*1000/(10**9)
total_inc['2003'] = total_inc['2003']*1000/(10**9)
total_inc['2004'] = total_inc['2004']*1000/(10**9)
total_inc['2005'] = total_inc['2005']*1000/(10**9)
total_inc['2006'] = total_inc['2006']*1000/(10**9)
total_inc['2007'] = total_inc['2007']*1000/(10**9)
total_inc['2008'] = total_inc['2008']*1000/(10**9)
total_inc['2009'] = total_inc['2009']*1000/(10**9)
total_inc['2010'] = total_inc['2010']*1000/(10**9)
total_inc['2011'] = total_inc['2011']*1000/(10**9)
total_inc['2012'] = total_inc['2012']*1000/(10**9)
total_inc['2013'] = total_inc['2013']*1000/(10**9)
total_inc['2014'] = total_inc['2014']*1000/(10**9)
total_inc['2015'] = total_inc['2015']*1000/(10**9)
total_inc['2016'] = total_inc['2016']*1000/(10**9)
total_inc['2017'] = total_inc['2017']*1000/(10**9)
total_inc['2018'] = total_inc['2018']*1000/(10**9)
```

```python
total_inc['01-18 Ab Inc'] = total_inc['01-18 Ab Inc']*1000/(10**9)
total_inc.head()

#For the personal income figures, we multiply each year column by 1000 and then divide said column by one billion.
```

[24]:

```
                                       Description      2001      2002  \
GeoName
Accomack, VA                       Personal income  0.798158  0.827094
Albemarle, VA                      Personal income  4.673545  4.769895
Alexandria (Independent City), VA  Personal income  6.970776  7.044342
Alleghany, VA                      Personal income  0.556362  0.566680
Amelia, VA                         Personal income  0.291481  0.291610

                                       2003      2004      2005      2006  \
GeoName
Accomack, VA                       0.881556  0.921178  0.955300  0.979101
Albemarle, VA                      5.104606  5.459814  5.877106  6.463224
Alexandria (Independent City), VA  7.308409  7.945125  8.480858  9.067312
Alleghany, VA                      0.588800  0.603056  0.618782  0.638739
Amelia, VA                         0.304391  0.339501  0.362798  0.386528

                                       2007      2008      2009  …  \
GeoName                                                          …
Accomack, VA                       1.033169  1.089135  1.092338  …
Albemarle, VA                      6.897809  7.167152  6.859572  …
Alexandria (Independent City), VA  9.318719  9.954991  9.963806  …
Alleghany, VA                      0.656422  0.707451  0.689865  …
Amelia, VA                         0.416917  0.418772  0.404473  …

                                        2011       2012       2013       2014  \
GeoName
Accomack, VA                        1.131424   1.185059   1.192333   1.234064
Albemarle, VA                       7.657164   8.457472   8.328130   8.935308
Alexandria (Independent City), VA  11.424532  12.143013  11.711094  12.316722
Alleghany, VA                       0.724411   0.767944   0.720625   0.738863
Amelia, VA                          0.437706   0.460323   0.494560   0.511085

                                        2015       2016       2017       2018  \
GeoName
Accomack, VA                        1.281707   1.288081   1.325930   1.386063
Albemarle, VA                       9.550724  10.091356  11.027862  11.702008
Alexandria (Independent City), VA  12.749013  13.027528  13.420320  14.127927
Alleghany, VA                       0.771583   0.774653   0.785845   0.816049
Amelia, VA                          0.539074   0.542679   0.558329   0.582640

                                   01-18 Ab Inc  01-18 Pct Inc
```

```
GeoName
Accomack, VA                            0.587905      73.657722
Albemarle, VA                           7.028463     150.388260
Alexandria (Independent City), VA       7.157151     102.673660
Alleghany, VA                           0.259687      46.675907
Amelia, VA                              0.291159      99.889526

[5 rows x 21 columns]
```

```
[25]: capita_inc = pop_inc[(pop_inc.Description == 'Per capita personal income')]
      capita_inc['01-18 Ab Capita'] = capita_inc['2018']-capita_inc['2001']
      capita_inc['01-18 Pct Capita'] = (capita_inc['2018']-capita_inc['2001'])/
       ↪capita_inc['2001']*100
      capita_inc.head()

      #We now calculate the absolute and relative changes in per-capita income␣
       ↪throughout Virginia from 2001 to 2018.
```

```
[25]:                                                    Description     Unit  \
      GeoName
      Accomack, VA                       Per capita personal income  Dollars
      Albemarle, VA                      Per capita personal income  Dollars
      Alexandria (Independent City), VA  Per capita personal income  Dollars
      Alleghany, VA                      Per capita personal income  Dollars
      Amelia, VA                         Per capita personal income  Dollars

                                            2001     2002     2003     2004  \
      GeoName
      Accomack, VA                       21148.0  22169.0  23993.0  25370.0
      Albemarle, VA                      36963.0  37382.0  39782.0  42072.0
      Alexandria (Independent City), VA  53240.0  53933.0  56470.0  61703.0
      Alleghany, VA                      23775.0  24388.0  25693.0  26407.0
      Amelia, VA                         25388.0  25269.0  26368.0  28987.0

                                            2005     2006     2007     2008  …  \
      GeoName                                                                …
      Accomack, VA                       26658.0  27822.0  29901.0  32062.0  …
      Albemarle, VA                      44432.0  47905.0  50516.0  51484.0  …
      Alexandria (Independent City), VA  66163.0  71018.0  72140.0  74878.0  …
      Alleghany, VA                      27316.0  28334.0  29062.0  31590.0  …
      Amelia, VA                         30377.0  31553.0  33495.0  33334.0  …

                                            2011     2012     2013     2014  \
      GeoName
      Accomack, VA                       34057.0  35626.0  36169.0  37430.0
      Albemarle, VA                      53190.0  57911.0  56544.0  59862.0
      Alexandria (Independent City), VA  79216.0  82429.0  78244.0  81336.0
```

```
Alleghany, VA                     32816.0  35104.0  33131.0  34563.0
Amelia, VA                        34324.0  36112.0  39068.0  40192.0

                                     2015     2016     2017     2018  \
GeoName
Accomack, VA                      38946.0  39211.0  40715.0  42764.0
Albemarle, VA                     63019.0  65680.0  70832.0  74613.0
Alexandria (Independent City), VA 82860.0  82954.0  84059.0  88008.0
Alleghany, VA                     36601.0  37033.0  38161.0  40061.0
Amelia, VA                        42174.0  42420.0  43064.0  44774.0

                                  01-18 Ab Capita  01-18 Pct Capita
GeoName
Accomack, VA                              21616.0        102.212975
Albemarle, VA                             37650.0        101.858612
Alexandria (Independent City), VA         34768.0         65.304283
Alleghany, VA                             16286.0         68.500526
Amelia, VA                                19386.0         76.358910

[5 rows x 22 columns]
```

[26]:

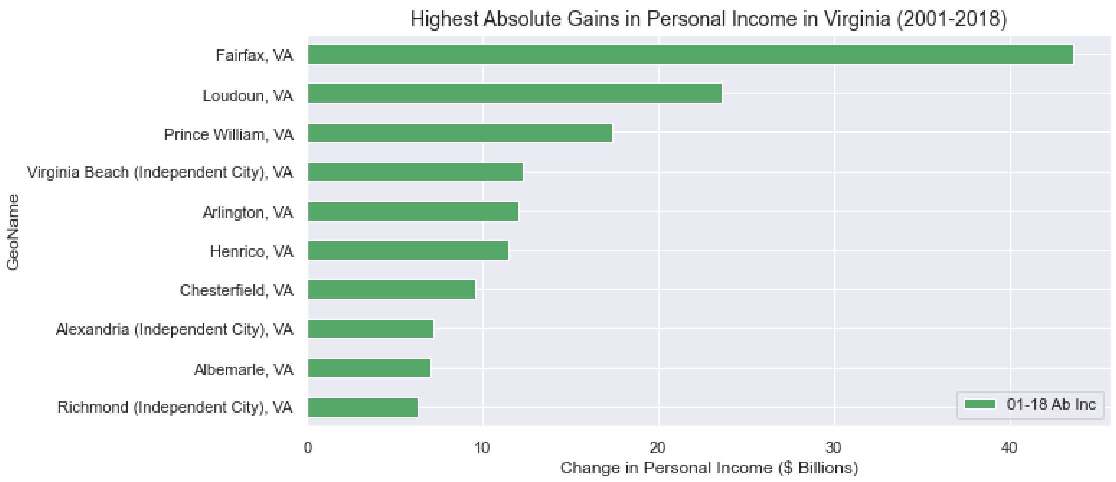
```
total_inc_ab = total_inc.iloc[:,[19]].sort_values(by='01-18 Ab Inc')
total_inc_pct = total_inc.iloc[:,[20]].sort_values(by='01-18 Pct Inc')

#We assemble the absolute changes in personal income together and sort the␣
 ↪figures from low to high in its own
#dataframe.  We also do this for the relative changes in personal income.
```

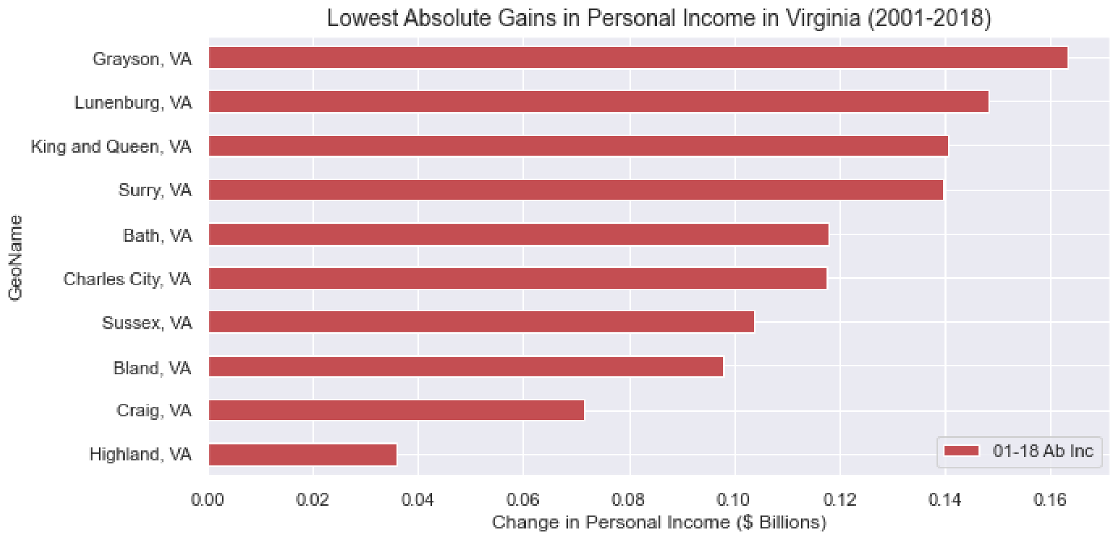
[27]:

```
capita_inc_ab = capita_inc.iloc[:,[20]].sort_values(by='01-18 Ab Capita')
capita_inc_pct = capita_inc.iloc[:,[21]].sort_values(by='01-18 Pct Capita')

#Much like we did earlier with personal income, we collect the absolute and␣
 ↪relative changes in per-capita income
#together and sort their individual dataframes from low to high.
```

[28]:

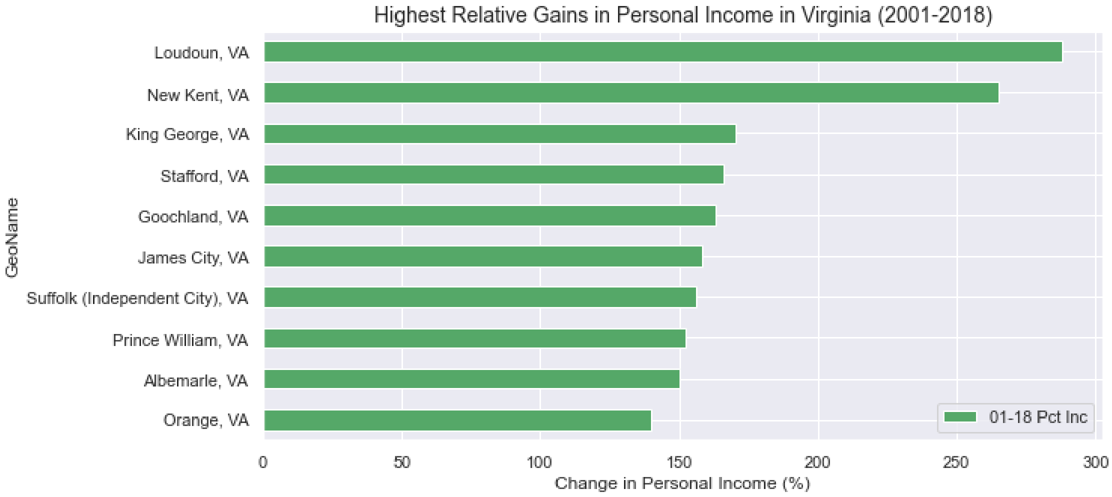
```
total_inc_ab.iloc[-10:].plot(kind='barh',color='g')
plt.title('Highest Absolute Gains in Personal Income in Virginia␣
 ↪(2001-2018)',size=14)
plt.xlabel('Change in Personal Income ($ Billions)')
plt.show()
print() #We allow an extra space between our graphs for convenience.

total_inc_ab.iloc[:10].plot(kind='barh',color='r')
plt.title('Lowest Absolute Gains in Personal Income in Virginia␣
 ↪(2001-2018)',size=14)
plt.xlabel('Change in Personal Income ($ Billions)')
plt.show()
```

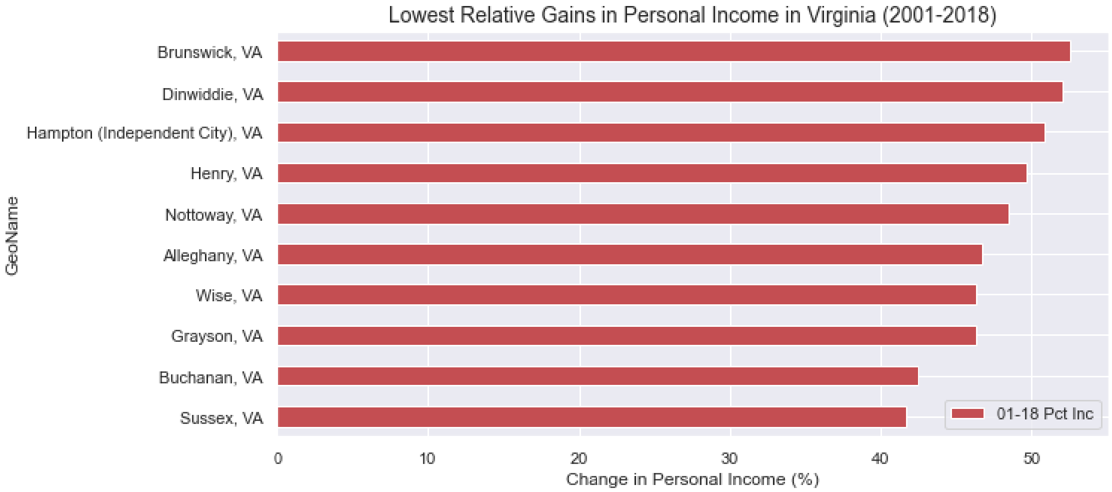




```
[29]: total_inc_pct.iloc[-10:].plot(kind='barh',color='g')
      plt.title('Highest Relative Gains in Personal Income in Virginia (2001-2018)',␣
       ↪size=14)
      plt.xlabel('Change in Personal Income (%)')
      plt.show()
      print()

      total_inc_pct.iloc[:10].plot(kind='barh',color='r')
      plt.title('Lowest Relative Gains in Personal Income in Virginia (2001-2018)',␣
       ↪size=14)
```

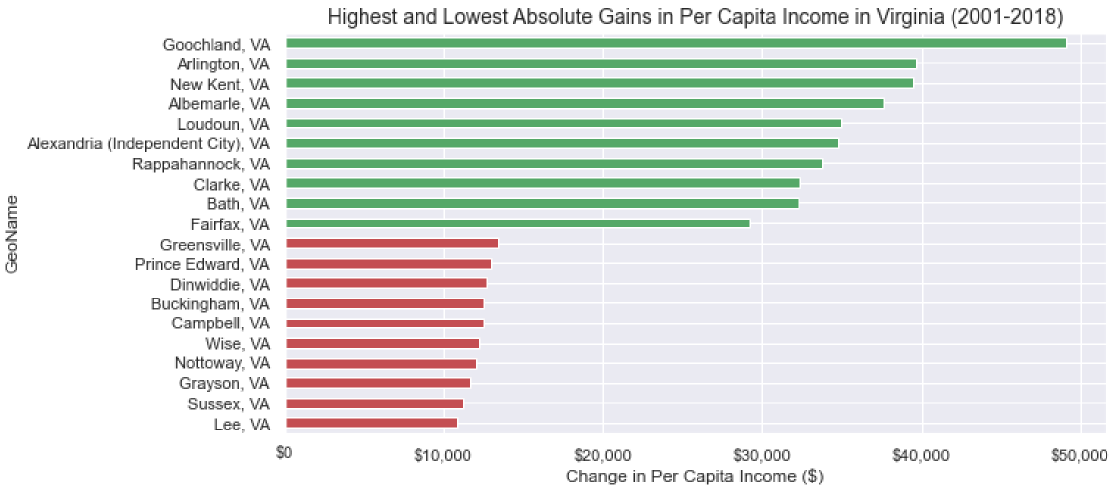
```
plt.xlabel('Change in Personal Income (%)')
plt.show()
```

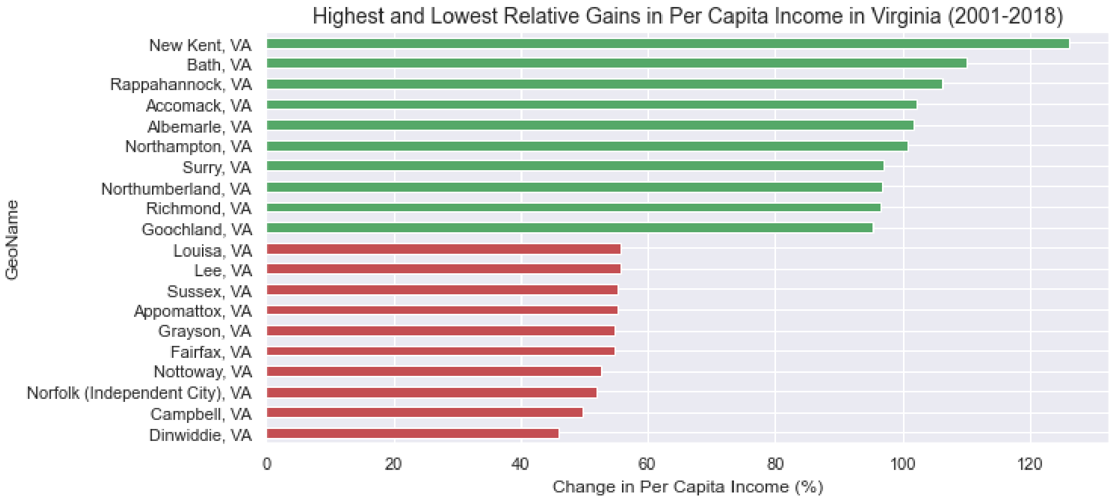




```
[30]: a = capita_inc_ab.iloc[np.r_[:10,-10:0],0].
       ↪plot(kind='barh',color=['r','r','r','r','r','r','r','r','r','r',
                                                                      ␣
       ↪'g','g','g','g','g','g','g','g','g','g'])
      plt.title('Highest and Lowest Absolute Gains in Per Capita Income in Virginia␣
       ↪(2001-2018)', size=14)
      plt.xlabel('Change in Per Capita Income ($)')
      fmt1 = '${x:,.0f}' #We format our X-axis in dollars separated by commas.
```

```
t1 = mtick.StrMethodFormatter(fmt1)
a.xaxis.set_major_formatter(t1)
plt.show()
print()

capita_inc_pct.iloc[np.r_[:10,-10:0],0].
 ↪plot(kind='barh',color=['r','r','r','r','r','r','r','r','r','r',
                                                            ␣
 ↪'g','g','g','g','g','g','g','g','g','g'])
plt.title('Highest and Lowest Relative Gains in Per Capita Income in Virginia␣
 ↪(2001-2018)', size=14)
plt.xlabel('Change in Per Capita Income (%)')
plt.show()
```





1.5 5. Evaluating Trends in Population

[31]:
```
pop = pop_inc[(pop_inc.Description == 'Population')]
pop['01-18 Ab Pop'] = pop['2018']-pop['2001']
pop['01-18 Pct Pop'] = (pop['2018']-pop['2001'])/pop['2001']*100
pop.head()

#We calculate the absolute and relative changes in population throughout␣
 ↪Virginia from 2001 to 2018.
```

[31]:
```
                                  Description             Unit      2001  \
GeoName
Accomack, VA                       Population  Number of persons   37742.0
Albemarle, VA                      Population  Number of persons  126438.0
Alexandria (Independent City), VA  Population  Number of persons  130932.0
Alleghany, VA                      Population  Number of persons   23401.0
Amelia, VA                         Population  Number of persons   11481.0

                                       2002      2003      2004      2005  \
GeoName
Accomack, VA                        37308.0   36742.0   36310.0   35835.0
Albemarle, VA                      127599.0  128315.0  129772.0  132273.0
Alexandria (Independent City), VA  130614.0  129421.0  128765.0  128181.0
Alleghany, VA                       23236.0   22917.0   22837.0   22653.0
Amelia, VA                          11540.0   11544.0   11712.0   11943.0

                                       2006      2003      2008  …  \
GeoName                                                          …
Accomack, VA                        35192.0   34553.0   33970.0  …
Albemarle, VA                      134918.0  136547.0  139211.0  …
Alexandria (Independent City), VA  127676.0  129175.0  132949.0  …
Alleghany, VA                       22543.0   22587.0   22395.0  …
Amelia, VA                          12250.0   12447.0   12563.0  …

                                       2011      2012      2013      2014  \
GeoName
Accomack, VA                        33221.0   33264.0   32966.0   32970.0
Albemarle, VA                      143960.0  146043.0  147286.0  149265.0
Alexandria (Independent City), VA  144220.0  147314.0  149674.0  151431.0
Alleghany, VA                       22075.0   21876.0   21751.0   21377.0
Amelia, VA                          12752.0   12747.0   12659.0   12716.0

                                       2015      2016      2017      2018  \
GeoName
```

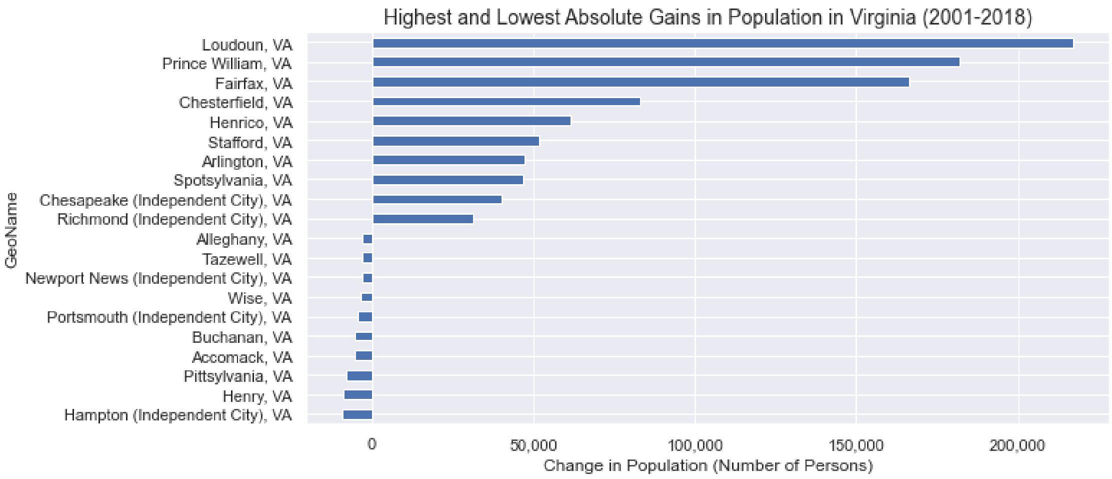
```
Accomack, VA                         32910.0   32850.0   32566.0   32412.0
Albemarle, VA                       151552.0  153644.0  155690.0  156835.0
Alexandria (Independent City), VA  153863.0  157045.0  159654.0  160530.0
Alleghany, VA                        21081.0   20918.0   20593.0   20370.0
Amelia, VA                           12782.0   12793.0   12965.0   13013.0

                                   01-18 Ab Pop  01-18 Pct Pop
GeoName
Accomack, VA                            -5330.0     -14.122198
Albemarle, VA                           30397.0      24.041031
Alexandria (Independent City), VA       29598.0      22.605627
Alleghany, VA                           -3031.0     -12.952438
Amelia, VA                               1532.0      13.343785

[5 rows x 22 columns]
```

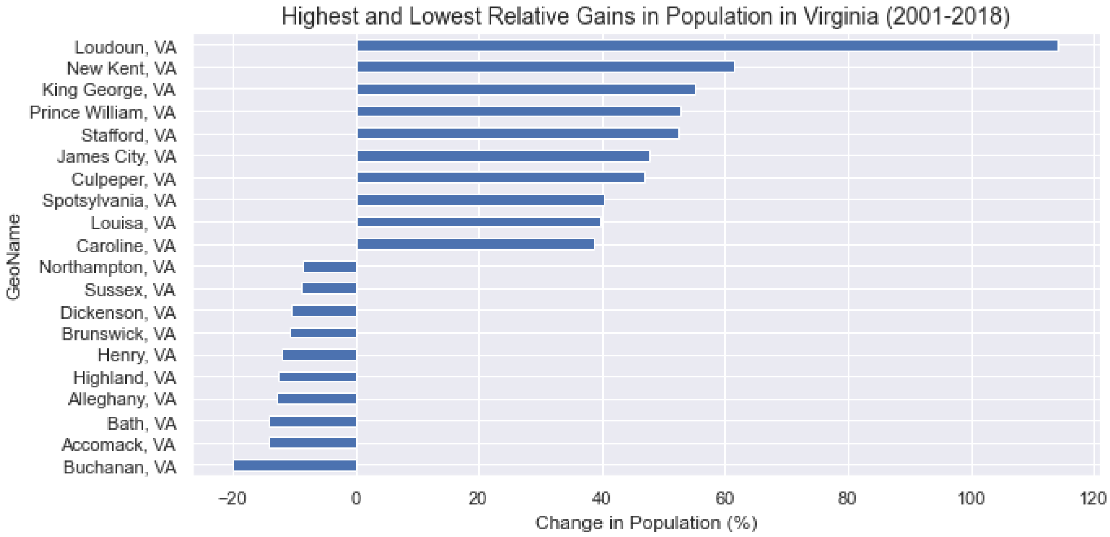
[32]:

```
pop_ab = pop.iloc[:,[20]].sort_values(by='01-18 Ab Pop')
pop_pct = pop.iloc[:,[21]].sort_values(by='01-18 Pct Pop')

#We create a dataframe sorting the absolute changes in population from low to␣
 ↪high, as well as for the relative
#changes.
```

[33]:

```
b = pop_ab.iloc[np.r_[:10,-10:0],0].plot(kind='barh')
plt.title('Highest and Lowest Absolute Gains in Population in Virginia␣
 ↪(2001-2018)', size=14)
plt.xlabel('Change in Population (Number of Persons)')
fmt2 = '{x:,.0f}' #We want to format our X-axis in terms of population figures␣
 ↪separated by commas.
t2 = mtick.StrMethodFormatter(fmt2)
b.xaxis.set_major_formatter(t2)
plt.show()
print()

pop_pct.iloc[np.r_[:10,-10:0],0].plot(kind='barh')
plt.title('Highest and Lowest Relative Gains in Population in Virginia␣
 ↪(2001-2018)', size=14)
plt.xlabel('Change in Population (%)')
plt.show()
```





1.6 6A. Evaluating Trends in GDP by Industry: Cleaning Up Our Data Further

[34]:

```
ind_gdp['Total GDP'] = ind_gdp.iloc[:,2:20].sum(axis=1)
ind_gdp.head()

#We sum up all the GDPs by industry for each area together.
```

[34]:

```
                                                     Description  \
GeoName
Accomack, VA  Educational services, health care, and social …
```

```
Accomack, VA  Finance, insurance, real estate, rental, and l…
Accomack, VA                                        Information
Accomack, VA                     Transportation and warehousing
Accomack, VA                                      Manufacturing

                              Unit      2001      2002      2003      2004  \
GeoName
Accomack, VA  Thousands of dollars   27223.0   28647.0   32077.0   37547.0
Accomack, VA  Thousands of dollars  143678.0  150373.0  164952.0  158824.0
Accomack, VA  Thousands of dollars   15629.0   23334.0   21770.0   13190.0
Accomack, VA  Thousands of dollars   11738.0   11791.0   11112.0   10361.0
Accomack, VA  Thousands of dollars  813624.0  694819.0  621442.0  565466.0

                  2005      2006      2007      2008  …       2010  \
GeoName                                               …
Accomack, VA   41549.0   42389.0   41554.0   48626.0  …    48325.0
Accomack, VA  181453.0  225503.0  242451.0  224833.0  …   232431.0
Accomack, VA   11943.0   10707.0   12199.0   13351.0  …    13023.0
Accomack, VA    9615.0    9953.0    9410.0    8689.0  …    10316.0
Accomack, VA  534804.0  582652.0  568388.0  681136.0  …  1362066.0

                   2011       2012       2013       2014       2015  \
GeoName
Accomack, VA    46856.0    50557.0        0.0        0.0        0.0
Accomack, VA   241862.0   243938.0   245562.0   251988.0   256643.0
Accomack, VA    11075.0     9689.0    10166.0     9991.0    10189.0
Accomack, VA    12152.0    15499.0        0.0        0.0        0.0
Accomack, VA  1330363.0  1441586.0  1510046.0  1565767.0  1752051.0

                   2016       2017       2018    Total GDP
GeoName
Accomack, VA        0.0        0.0        0.0     495784.0
Accomack, VA   263338.0   266813.0   278947.0    4010465.0
Accomack, VA    10822.0    10962.0    10824.0     232184.0
Accomack, VA        0.0        0.0        0.0     128772.0
Accomack, VA  1802328.0  1804397.0  1852963.0   20685860.0

[5 rows x 21 columns]
```

[35]:

```python
utilities = ind_gdp[(ind_gdp.Description=='Utilities')]
construct = ind_gdp[(ind_gdp.Description=='Construction')]
manu = ind_gdp[(ind_gdp.Description=='Manufacturing')]
transport = ind_gdp[(ind_gdp.Description=='Transportation and warehousing')]
info = ind_gdp[(ind_gdp.Description=='Information')]
finance = ind_gdp[(ind_gdp.Description=='Finance, insurance, real estate, rental, and leasing')]
prof = ind_gdp[(ind_gdp.Description=='Professional and business services')]
```

```
educ_health = ind_gdp[(ind_gdp.Description=='Educational services, health care,␣
 ↪and social assistance')]
arts = ind_gdp[(ind_gdp.Description=='Arts, entertainment, recreation,␣
 ↪accommodation, and food services')]
other = ind_gdp[(ind_gdp.Description=='Other services (except government and␣
 ↪government enterprises)')]
govt = ind_gdp[(ind_gdp.Description=='Government and government enterprises')]
natural = ind_gdp[(ind_gdp.Description=='Natural resources and mining')]
trade = ind_gdp[(ind_gdp.Description=='Trade')]

#Each industry gets assigned to its own dataframe.
```

[36]:

```
utilities = utilities.iloc[:,[0,1,20]]
construct = construct.iloc[:,[0,1,20]]
manu = manu.iloc[:,[0,1,20]]
transport = transport.iloc[:,[0,1,20]]
info = info.iloc[:,[0,1,20]]
finance = finance.iloc[:,[0,1,20]]
prof = prof.iloc[:,[0,1,20]]
educ_health = educ_health.iloc[:,[0,1,20]]
arts = arts.iloc[:,[0,1,20]]
other = other.iloc[:,[0,1,20]]
govt = govt.iloc[:,[0,1,20]]
natural = natural.iloc[:,[0,1,20]]
trade = trade.iloc[:,[0,1,20]]

#We isolate each industry's total GDP.
```

[37]:

```
gdp = [utilities['Total GDP'] + construct['Total GDP'] + manu['Total GDP'] +␣
 ↪transport['Total GDP'] +
       info['Total GDP'] + finance['Total GDP'] + prof['Total GDP'] +␣
 ↪educ_health['Total GDP'] +
       arts['Total GDP'] + other['Total GDP'] + govt['Total GDP'] +␣
 ↪natural['Total GDP'] + trade['Total GDP']]
gdp = pd.DataFrame(gdp)
gdp

#We now sum up all the industry GDPs incorporating the years 2001 through 2018␣
 ↪together, and proceed to create a new
#dataframe including those sums by area.
```

[37]:

```
GeoName    Accomack, VA  Albemarle, VA  Alexandria (Independent City), VA  \
Total GDP    37336052.0    141730624.0                        228049472.0

GeoName    Alleghany, VA  Amelia, VA  Amherst, VA  Appomattox, VA  \
Total GDP      8931257.0   4697019.0   12311982.0       4395793.0
```

```
GeoName    Arlington, VA  Augusta, VA   Bath, VA  …   Surry, VA  Sussex, VA  \
Total GDP    471951968.0   56712216.0  3674678.0  …  18958412.0   5036141.0

GeoName    Tazewell, VA  Virginia Beach (Independent City), VA  Warren, VA  \
Total GDP    22774316.0                            320266944.0  17086276.0

GeoName    Washington, VA  Westmoreland, VA    Wise, VA   Wythe, VA  \
Total GDP      38672556.0         6002795.0  28135840.0  20131536.0

GeoName      York, VA
Total GDP  34244952.0

[1 rows x 105 columns]
```

[38]:

```
gdp = gdp.transpose()
gdp['Total GDP'] = gdp['Total GDP']*1000/(10**9)
gdp.head()

#We transpose the shape of our dataframe by allocating the cities and counties␣
 ↪under the index column and rename our
#value column to 'Total GDP' for consistency.  In addition, upon observing from␣
 ↪our previous database that our units
#were in thousands of dollars, we convert our total GDP figures into billions␣
 ↪here.
```

[38]:

```
                                    Total GDP
GeoName
Accomack, VA                        37.336052
Albemarle, VA                      141.730628
Alexandria (Independent City), VA  228.049469
Alleghany, VA                        8.931257
Amelia, VA                           4.697019
```

[39]:

```
gdp['Utilities'] = utilities['Total GDP']*1000/(10**9)
gdp['Construction'] = construct['Total GDP']*1000/(10**9)
gdp['Manufacturing'] = manu['Total GDP']*1000/(10**9)
gdp['Transportation'] = transport['Total GDP']*1000/(10**9)
gdp['Information'] = info['Total GDP']*1000/(10**9)
gdp['Finance'] = finance['Total GDP']*1000/(10**9)
gdp['Professional Services'] = prof['Total GDP']*1000/(10**9)
gdp['Education / Health'] = educ_health['Total GDP']*1000/(10**9)
gdp['Entertainment'] = arts['Total GDP']*1000/(10**9)
gdp['Other Services'] = other['Total GDP']*1000/(10**9)
gdp['Government'] = govt['Total GDP']*1000/(10**9)
gdp['Natural Resources'] = natural['Total GDP']*1000/(10**9)
gdp['Trade'] = trade['Total GDP']*1000/(10**9)
```

```
gdp.head()

#Each industry's total GDP from 2001 to 2018 gets its own column and also␣
 ↪converts into billions.
```

[39]:

```
                                    Total GDP  Utilities  Construction  \
GeoName
Accomack, VA                        37.336052   0.244069      0.748364
Albemarle, VA                      141.730628   0.304137      6.472961
Alexandria (Independent City), VA  228.049469   0.240045      6.430297
Alleghany, VA                        8.931257   0.536721      0.459170
Amelia, VA                           4.697019   0.023576      0.464110

                                   Manufacturing  Transportation  Information  \
GeoName
Accomack, VA                           20.685861        0.128772     0.232184
Albemarle, VA                           4.706183        0.000000     6.013587
Alexandria (Independent City), VA       0.619851        3.040367     8.874366
Alleghany, VA                           0.494300        0.346161     0.000000
Amelia, VA                              0.364205        0.058966     0.021735

                                     Finance  Professional Services  \
GeoName
Accomack, VA                        4.010465               2.005698
Albemarle, VA                      31.993336              18.624649
Alexandria (Independent City), VA  47.857111              58.837185
Alleghany, VA                       2.437811               0.686992
Amelia, VA                          0.855842               0.410122

                                   Education / Health  Entertainment  \
GeoName
Accomack, VA                                 0.495784       0.762874
Albemarle, VA                               13.134388       6.833805
Alexandria (Independent City), VA           10.861439       6.388713
Alleghany, VA                                1.010971       0.293714
Amelia, VA                                   0.264835       0.043624

                                   Other Services  Government  \
GeoName
Accomack, VA                             0.516269    3.920432
Albemarle, VA                            4.586272   43.129623
Alexandria (Independent City), VA       16.594492   56.774373
Alleghany, VA                            0.380599    1.645292
Amelia, VA                               0.154925    0.580338

                                   Natural Resources      Trade
GeoName
```

```
Accomack, VA                                1.941237   1.644048
Albemarle, VA                               0.169251   5.762429
Alexandria (Independent City), VA           0.000972  11.530259
Alleghany, VA                               0.012304   0.627222
Amelia, VA                                  0.766819   0.687922
```

[40]:

```
gdp['Utilities Share'] = gdp['Utilities']/gdp['Total GDP']*100
gdp['Construction Share'] = gdp['Construction']/gdp['Total GDP']*100
gdp['Manufacturing Share'] = gdp['Manufacturing']/gdp['Total GDP']*100
gdp['Transportation Share'] = gdp['Transportation']/gdp['Total GDP']*100
gdp['Information Share'] = gdp['Information']/gdp['Total GDP']*100
gdp['Finance Share'] = gdp['Finance']/gdp['Total GDP']*100
gdp['Professional Services Share'] = gdp['Professional Services']/gdp['Total␣
 ↪GDP']*100
gdp['Education / Health Share'] = gdp['Education / Health']/gdp['Total GDP']*100
gdp['Entertainment Share'] = gdp['Entertainment']/gdp['Total GDP']*100
gdp['Other Services Share'] = gdp['Other Services']/gdp['Total GDP']*100
gdp['Government Share'] = gdp['Government']/gdp['Total GDP']*100
gdp['Natural Resources Share'] = gdp['Natural Resources']/gdp['Total GDP']*100
gdp['Trade Share'] = gdp['Trade']/gdp['Total GDP']*100
gdp.head()

#We calculate industry's share of total GDP from 2001 to 2018.
```

[40]:

```
                                    Total GDP  Utilities  Construction  \
GeoName
Accomack, VA                        37.336052   0.244069      0.748364
Albemarle, VA                      141.730628   0.304137      6.472961
Alexandria (Independent City), VA  228.049469   0.240045      6.430297
Alleghany, VA                        8.931257   0.536721      0.459170
Amelia, VA                           4.697019   0.023576      0.464110

                                   Manufacturing  Transportation  Information  \
GeoName
Accomack, VA                           20.685861        0.128772     0.232184
Albemarle, VA                           4.706183        0.000000     6.013587
Alexandria (Independent City), VA       0.619851        3.040367     8.874366
Alleghany, VA                           0.494300        0.346161     0.000000
Amelia, VA                              0.364205        0.058966     0.021735

                                     Finance  Professional Services  \
GeoName
Accomack, VA                        4.010465               2.005698
Albemarle, VA                      31.993336              18.624649
Alexandria (Independent City), VA  47.857111              58.837185
Alleghany, VA                       2.437811               0.686992
Amelia, VA                          0.855842               0.410122
```

```
                                   Education / Health  Entertainment  …  \
GeoName                                                               …
Accomack, VA                                 0.495784       0.762874  …
Albemarle, VA                               13.134388       6.833805  …
Alexandria (Independent City), VA           10.861439       6.388713  …
Alleghany, VA                                1.010971       0.293714  …
Amelia, VA                                   0.264835       0.043624  …

                                   Transportation Share  Information Share  \
GeoName
Accomack, VA                                   0.344900           0.621876
Albemarle, VA                                  0.000000           4.242969
Alexandria (Independent City), VA              1.333205           3.891421
Alleghany, VA                                  3.875837           0.000000
Amelia, VA                                     1.255392           0.462740

                                   Finance Share  Professional Services Share  \
GeoName
Accomack, VA                           10.741535                     5.372014
Albemarle, VA                          22.573340                    13.140878
Alexandria (Independent City), VA      20.985408                    25.800185
Alleghany, VA                          27.295272                     7.691996
Amelia, VA                             18.220961                     8.731538

                                   Education / Health Share  \
GeoName
Accomack, VA                                       1.327896
Albemarle, VA                                      9.267149
Alexandria (Independent City), VA                  4.762756
Alleghany, VA                                     11.319470
Amelia, VA                                         5.638364

                                   Entertainment Share  Other Services Share  \
GeoName
Accomack, VA                                  2.043264              1.382763
Albemarle, VA                                 4.821685              3.235907
Alexandria (Independent City), VA             2.801459              7.276707
Alleghany, VA                                 3.288607              4.261427
Amelia, VA                                    0.928759              3.298369

                                   Government Share  Natural Resources Share  \
GeoName
Accomack, VA                              10.500393                 5.199363
Albemarle, VA                             30.430700                 0.119417
Alexandria (Independent City), VA         24.895639                 0.000426
Alleghany, VA                             18.421729                 0.137763
```

```
Amelia, VA                                12.355454                16.325653

                                   Trade Share
GeoName
Accomack, VA                          4.403379
Albemarle, VA                         4.065761
Alexandria (Independent City), VA     5.056034
Alleghany, VA                         7.022774
Amelia, VA                           14.645928

[5 rows x 27 columns]
```

1.7 6B. Evaluating Trends in GDP by Industry: Comparing Between Areas' Industry Contributions

[41]:

```
def topnine(industry, total=9):
    df = gdp[industry]
    top = df.sort_values(ascending=False)
    top = top.reset_index().head(total)
    top.index = top.index + 1
    return top

#We create a function indicating the top 9 areas in terms of their GDP␣
 ↪contribution for a given industry from 2001 to
#2018.
```

[42]:

```
topnine('Utilities')
```

[42]:

```
                             GeoName  Utilities
1                         Louisa, VA  18.829410
2                          Surry, VA  16.535195
3                   Chesterfield, VA   9.212141
4                       Fluvanna, VA   4.374536
5                 Prince William, VA   3.785981
6                        Hanover, VA   3.003706
7                        Fairfax, VA   2.948026
8  Chesapeake (Independent City), VA   2.815059
9                        Russell, VA   2.275161
```

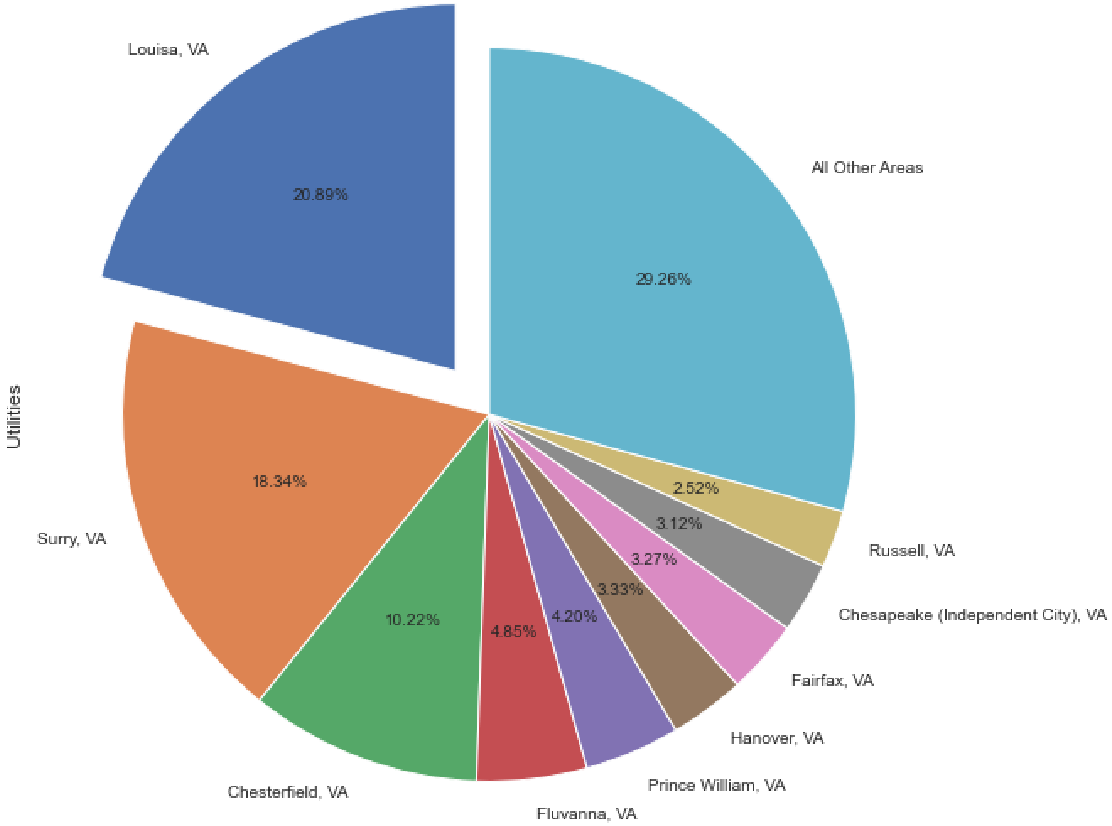
[43]:

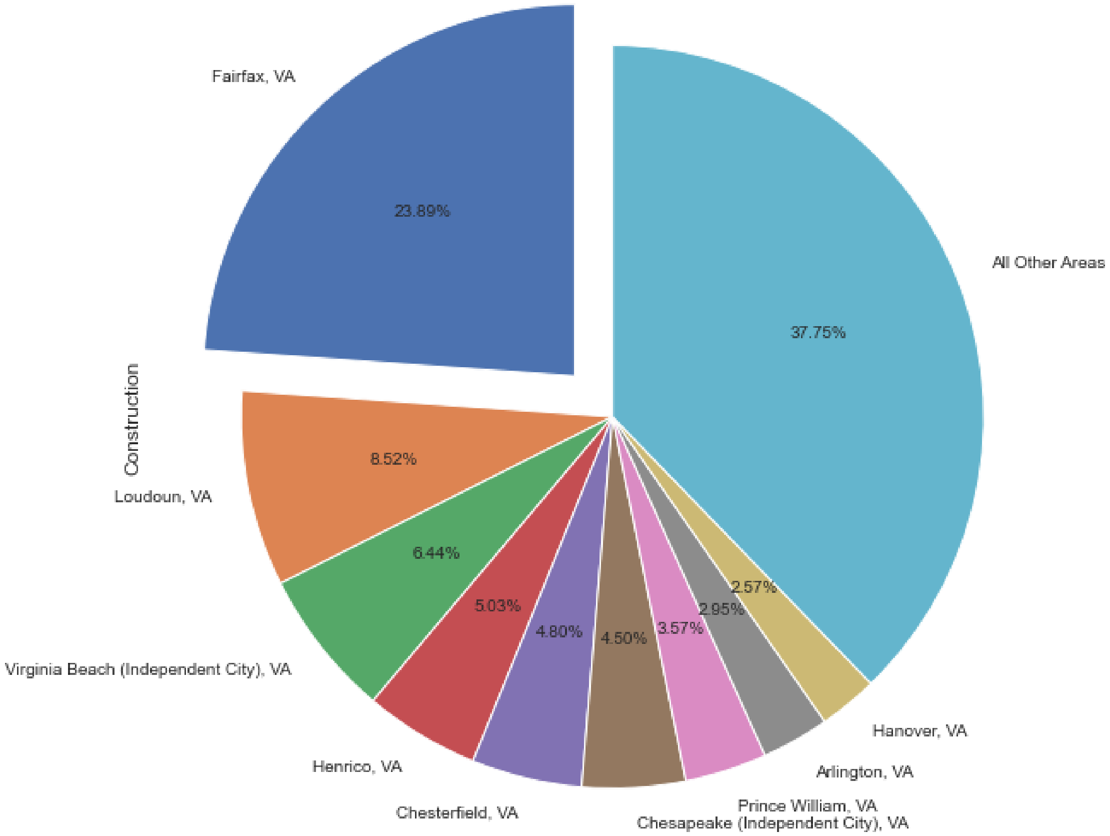
```
def GeoPlot(industry):
    df = gdp[industry]
    top = df.sort_values(ascending=False)
    top = top.reset_index()
    top.index = top.index + 1
    others = top[9:].sum()[1]
    top = top[:9]
    top.loc[10] = ('All Other Areas', others)

    plot1 = top[industry].plot.pie(subplots=True,
                                   autopct='%0.2f%%',
                                   fontsize=10,
                                   figsize=(10,10),
                                   legend=False,
                                   labels=top['GeoName'],
                                   shadow=False,
                                   explode=(0.15,0,0,0,0,0,0,0,0,0,0), #We␣
↪explode the most significant area here.
                                   startangle=90)
```

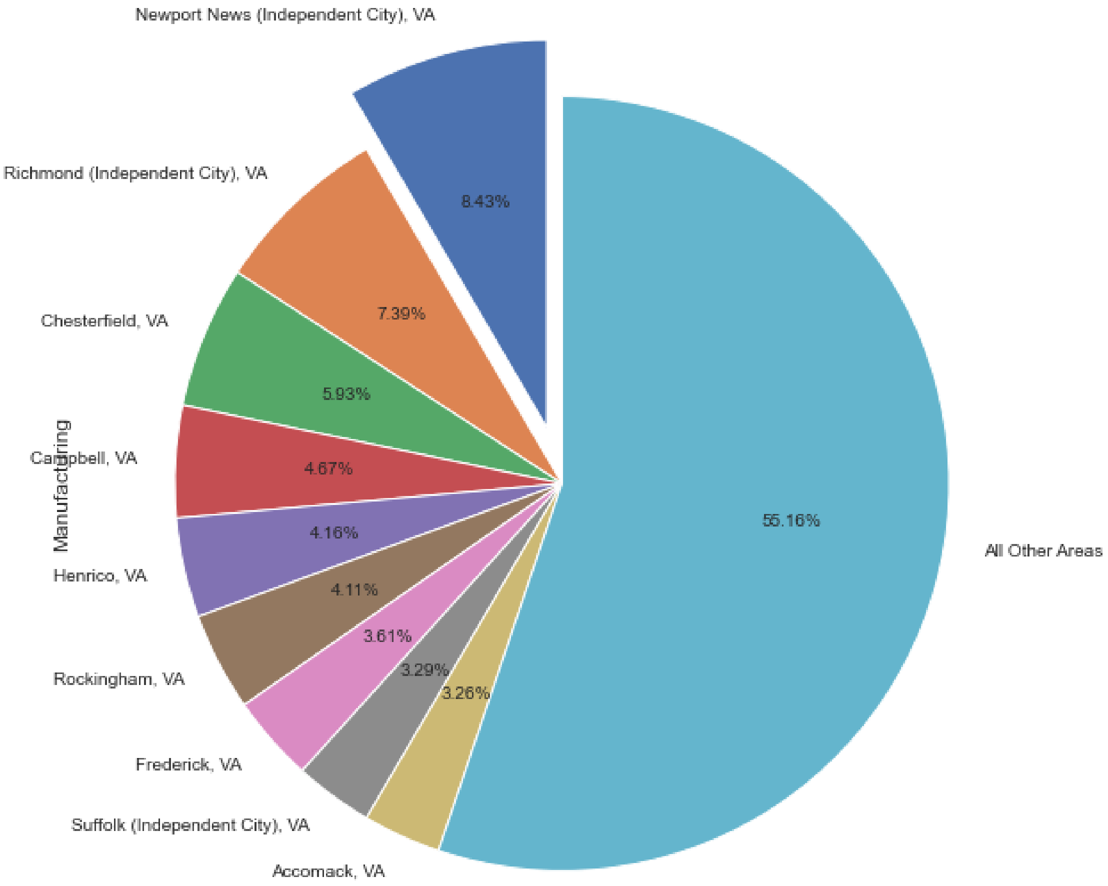
[44]:

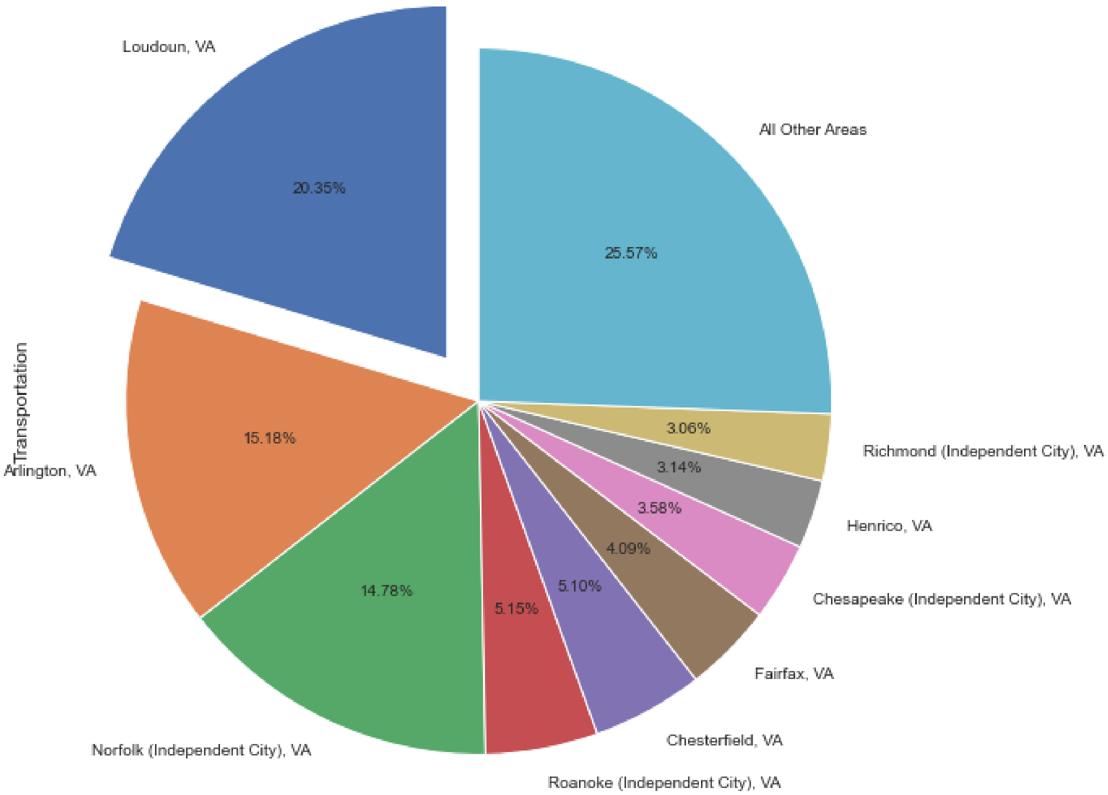
```
GeoPlot('Utilities')
plt.show()
print()
GeoPlot('Construction')
plt.show()
print()
GeoPlot('Manufacturing')
plt.show()
print()
GeoPlot('Transportation')
plt.show()
print()
GeoPlot('Information')
plt.show()
print()
GeoPlot('Finance')
plt.show()
print()
GeoPlot('Professional Services')
plt.show()
print()
GeoPlot('Education / Health')
plt.show()
print()
GeoPlot('Entertainment')
plt.show()
print()
GeoPlot('Other Services')
plt.show()
print()
GeoPlot('Government')
plt.show()
print()
GeoPlot('Manufacturing')
```

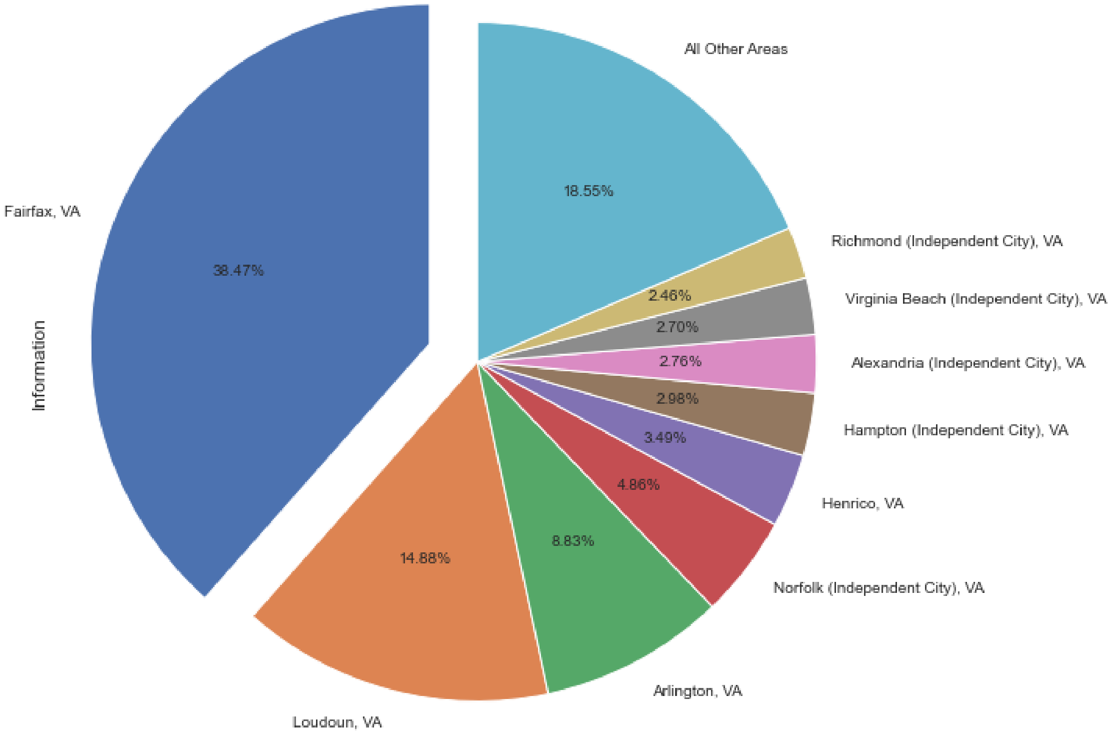
```
plt.show()
print()
GeoPlot('Natural Resources')
plt.show()
print()
GeoPlot('Trade')
plt.show()
```

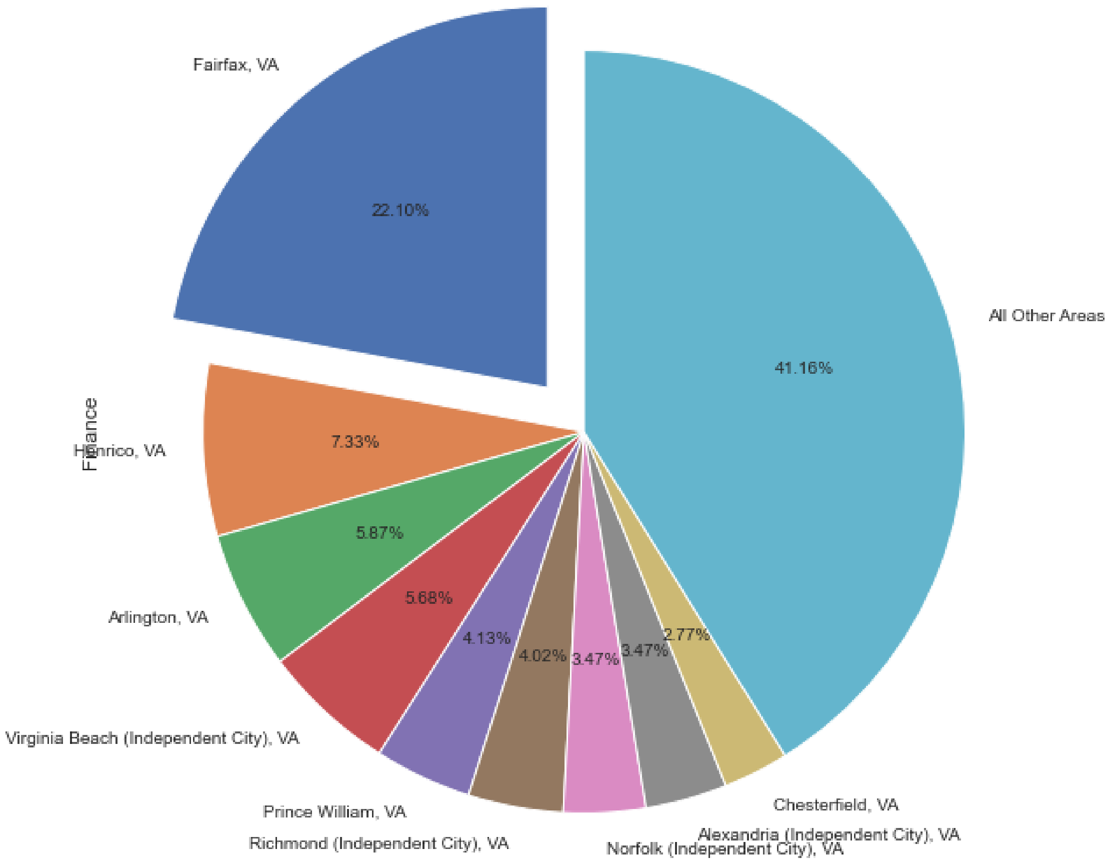


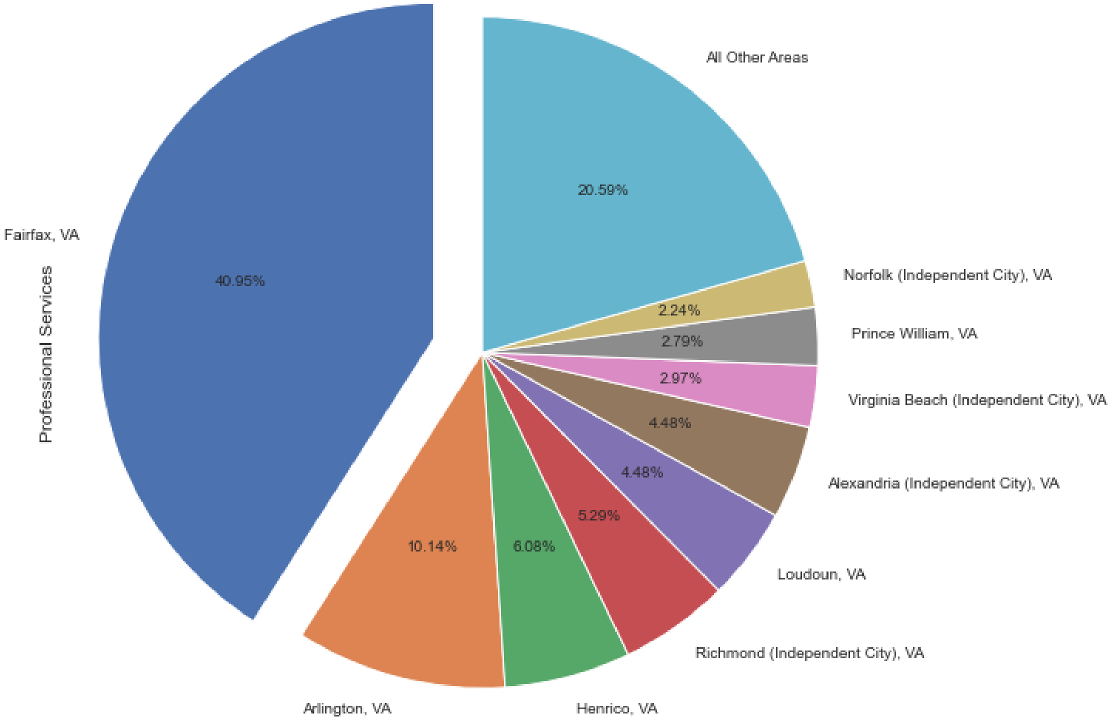

Construction
Fairfax, VA
23.89%
All Other Areas
37.75%
Loudoun, VA
8.52%
Virginia Beach (Independent City), VA
6.44%
Henrico, VA
5.03%
Chesterfield, VA
4.80%
Chesapeake (Independent City), VA
4.50%
Prince William, VA
3.57%
Arlington, VA
2.95%
Hanover, VA
2.57%

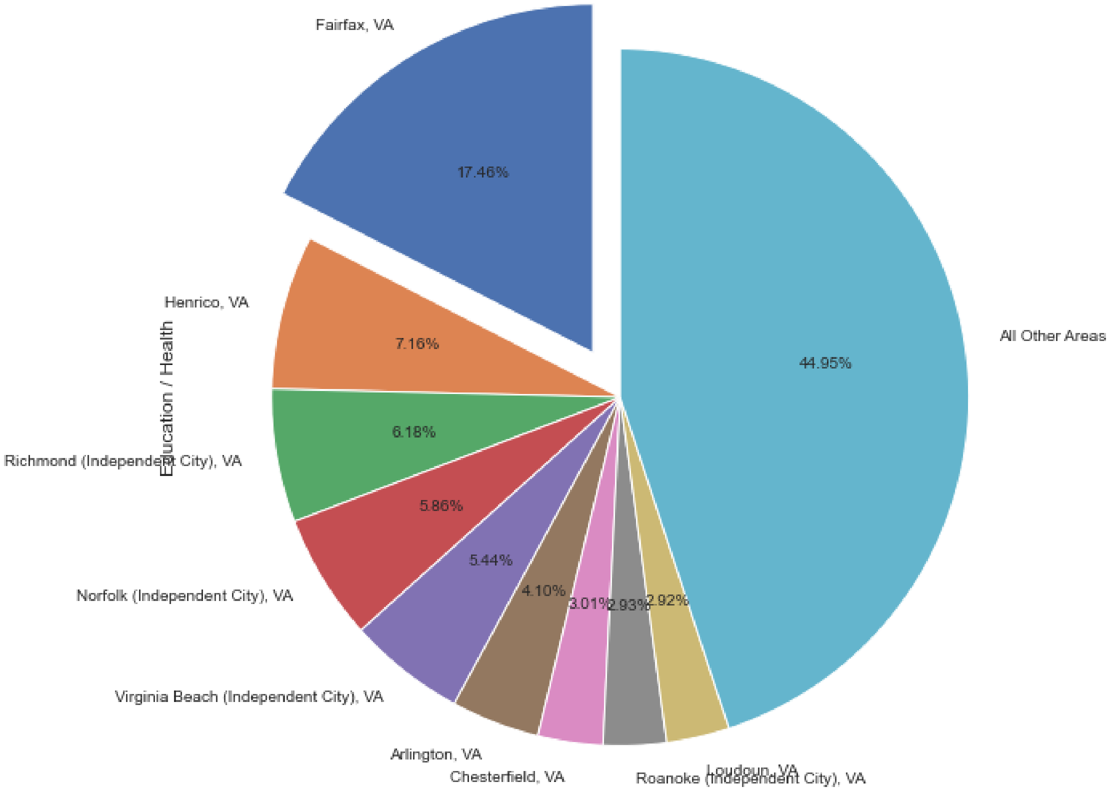

Manufacturing
Newport News (Independent City), VA
8.43%
Richmond (Independent City), VA
7.39%
Chesterfield, VA
5.93%
Campbell, VA
4.67%
Henrico, VA
4.16%
Rockingham, VA
4.11%
Frederick, VA
3.61%
Suffolk (Independent City), VA
3.29%
Accomack, VA
3.26%
All Other Areas
55.16%

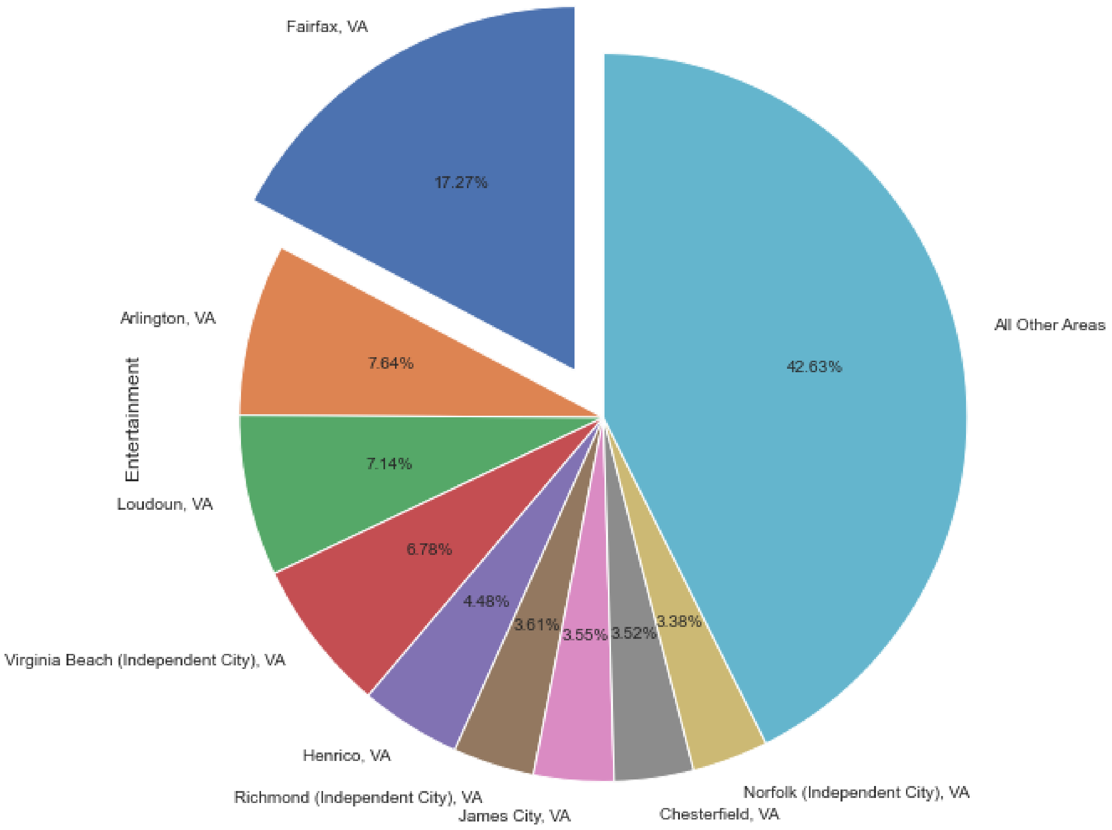

Transportation
Loudoun, VA
20.35%
All Other Areas
25.57%
Arlington, VA
15.18%
Norfolk (Independent City), VA
14.78%
Roanoke (Independent City), VA
5.15%
Chesterfield, VA
5.10%
Fairfax, VA
4.09%
Chesapeake (Independent City), VA
3.58%
Henrico, VA
3.14%
Richmond (Independent City), VA
3.06%

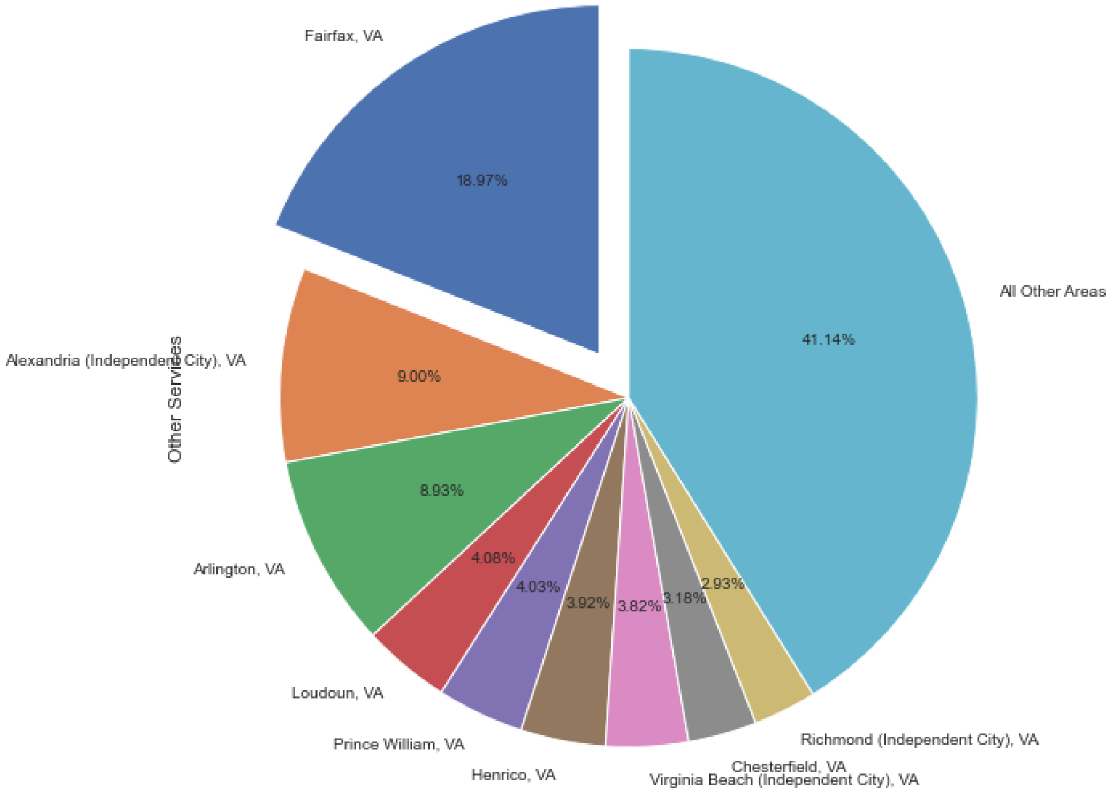

Information
All Other Areas
18.55%
Fairfax, VA
38.47%
Richmond (Independent City), VA
2.46%
Virginia Beach (Independent City), VA
2.70%
Alexandria (Independent City), VA
2.76%
Hampton (Independent City), VA
2.98%
Henrico, VA
3.49%
Norfolk (Independent City), VA
4.86%
Arlington, VA
8.83%
Loudoun, VA
14.88%

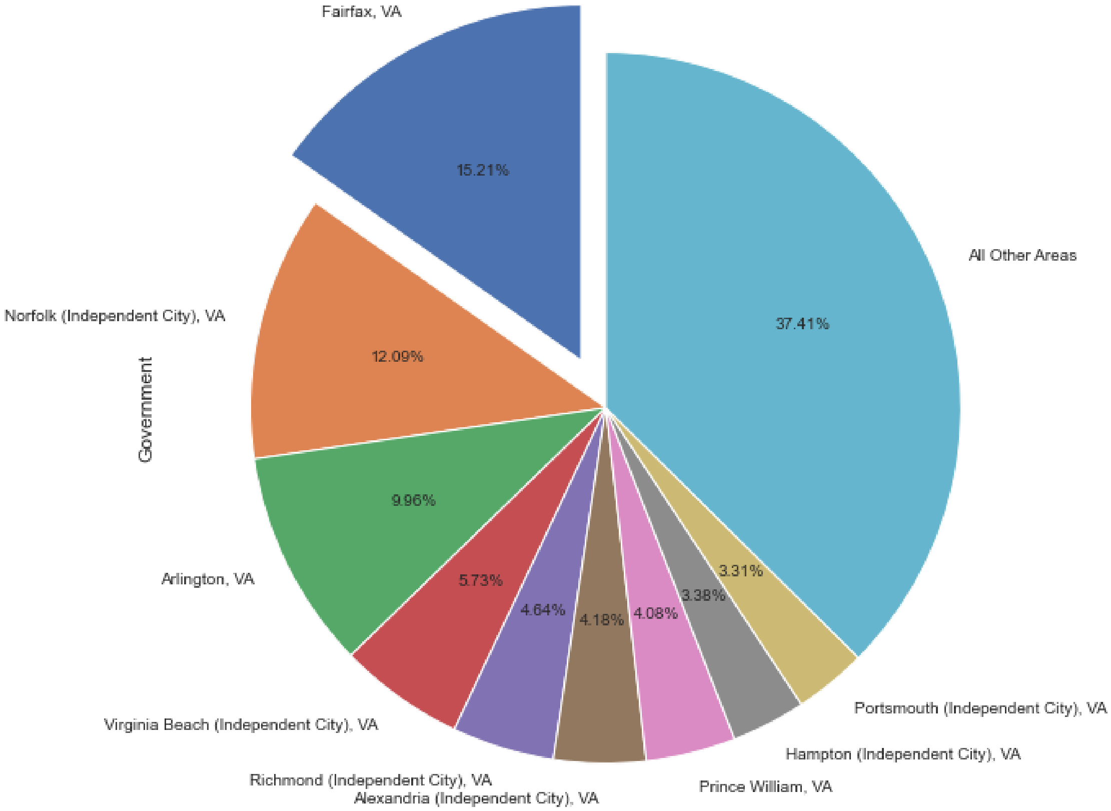

Finance
Fairfax, VA
22.10%
All Other Areas
41.16%
Henrico, VA
7.33%
Arlington, VA
5.87%
Virginia Beach (Independent City), VA
5.68%
Prince William, VA
4.13%
Richmond (Independent City), VA
4.02%
Norfolk (Independent City), VA
3.47%
Alexandria (Independent City), VA
3.47%
Chesterfield, VA
2.77%

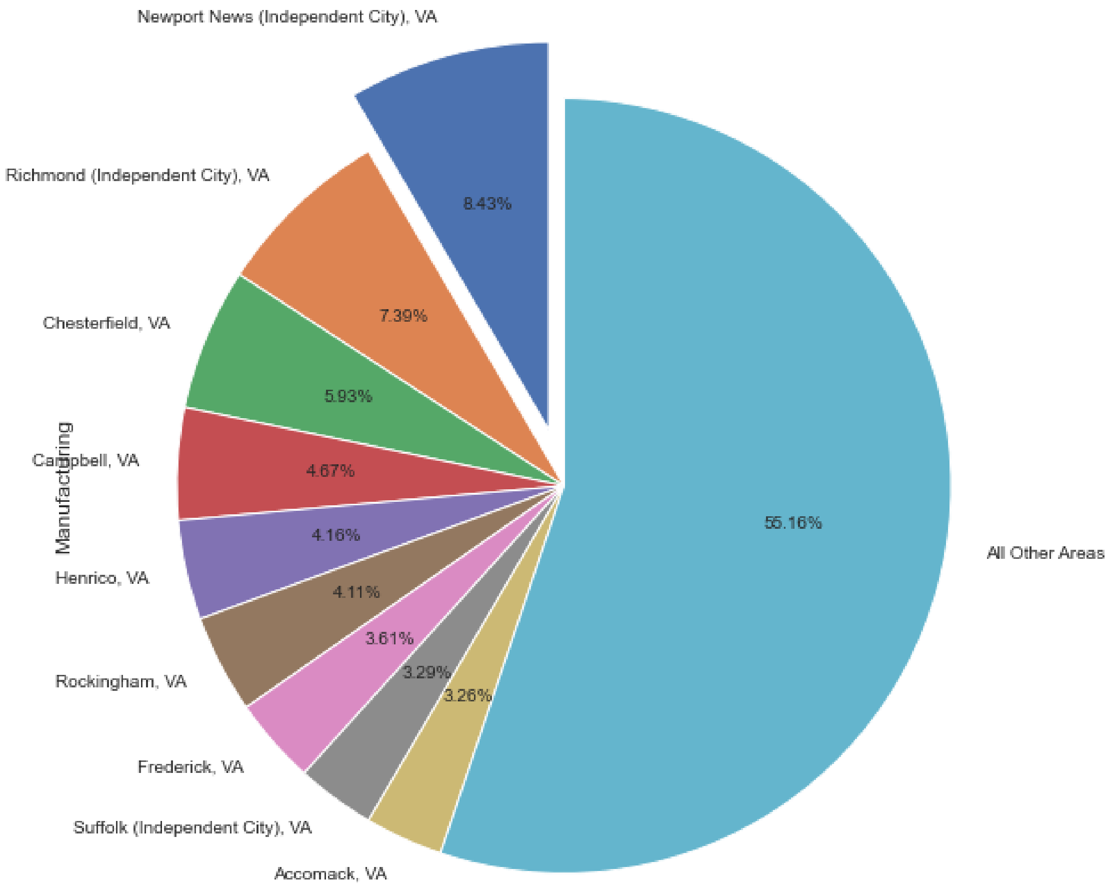

Professional Services
Fairfax, VA
40.95%
All Other Areas
20.59%
Norfolk (Independent City), VA
2.24%
Prince William, VA
2.79%
Virginia Beach (Independent City), VA
2.97%
Alexandria (Independent City), VA
4.48%
Loudoun, VA
4.48%
Richmond (Independent City), VA
5.29%
Henrico, VA
6.08%
Arlington, VA
10.14%

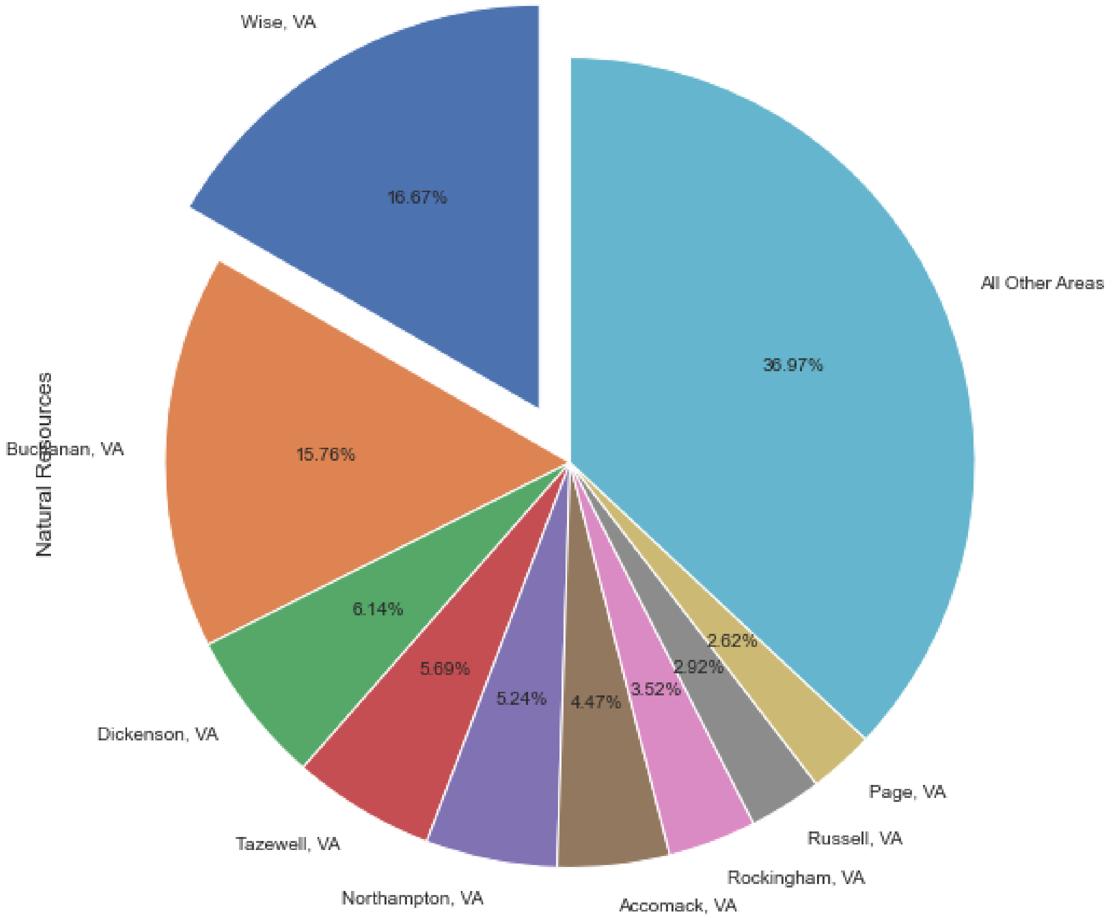

Education / Health
Fairfax, VA
17.46%
Henrico, VA
7.16%
Richmond (Independent City), VA
6.18%
Norfolk (Independent City), VA
5.86%
Virginia Beach (Independent City), VA
5.44%
Arlington, VA
4.10%
Chesterfield, VA
3.01%
Roanoke (Independent City), VA
2.93%
Loudoun, VA
2.92%
All Other Areas
44.95%

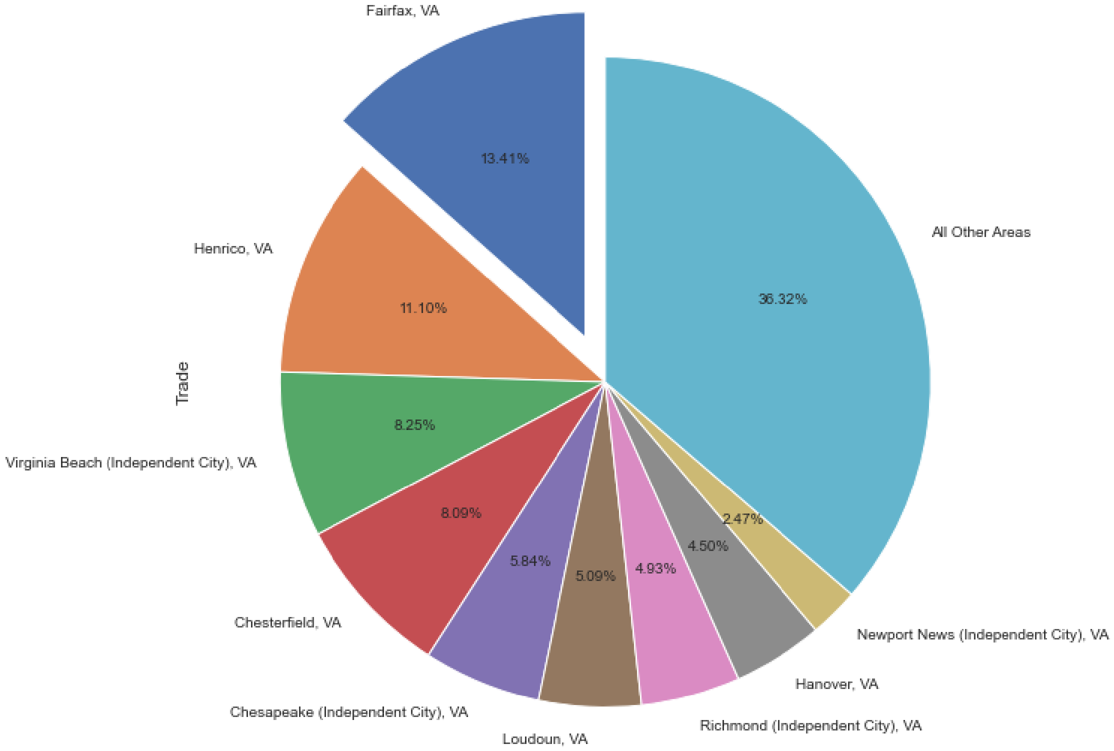

Fairfax, VA
17.27%
Arlington, VA
7.64%
Entertainment
7.14%
Loudoun, VA
6.78%
Virginia Beach (Independent City), VA
4.48%
3.61%
3.55%
3.52%
3.38%
Henrico, VA
Richmond (Independent City), VA
James City, VA
Chesterfield, VA
Norfolk (Independent City), VA
42.63%
All Other Areas


Other Services
Fairfax, VA
18.97%
All Other Areas
41.14%
Alexandria (Independent City), VA
9.00%
8.93%
Arlington, VA
4.08%
4.03%
3.92%
3.82%
3.18%
2.93%
Loudoun, VA
Prince William, VA
Henrico, VA
Richmond (Independent City), VA
Chesterfield, VA
Virginia Beach (Independent City), VA


Fairfax, VA
15.21%
All Other Areas
37.41%
Norfolk (Independent City), VA
12.09%
Government
9.96%
Arlington, VA
5.73%
4.64%
4.18%
4.08%
3.38%
3.31%
Portsmouth (Independent City), VA
Virginia Beach (Independent City), VA
Hampton (Independent City), VA
Richmond (Independent City), VA
Alexandria (Independent City), VA
Prince William, VA


Newport News (Independent City), VA
8.43%
Richmond (Independent City), VA
7.39%
Chesterfield, VA
5.93%
Campbell, VA
4.67%
Manufacturing
Henrico, VA
4.16%
Rockingham, VA
4.11%
Frederick, VA
3.61%
Suffolk (Independent City), VA
3.29%
Accomack, VA
3.26%
All Other Areas
55.16%


Natural Resources
Wise, VA
16.67%
All Other Areas
36.97%
Buchanan, VA
15.76%
6.14%
Dickenson, VA
5.69%
Tazewell, VA
5.24%
Northampton, VA
4.47%
Accomack, VA
3.52%
Rockingham, VA
2.92%
Russell, VA
2.62%
Page, VA

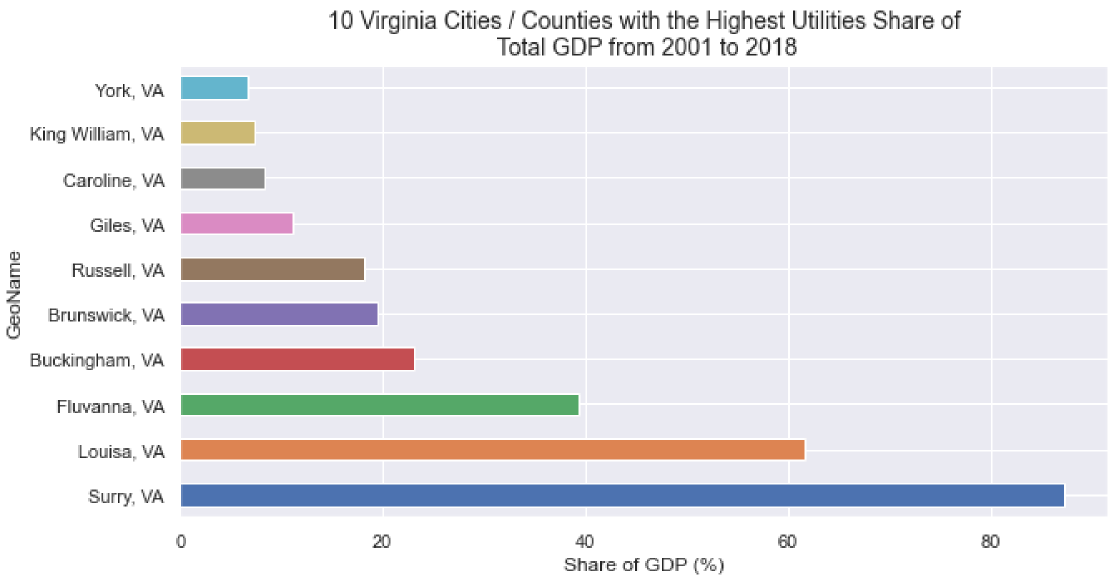


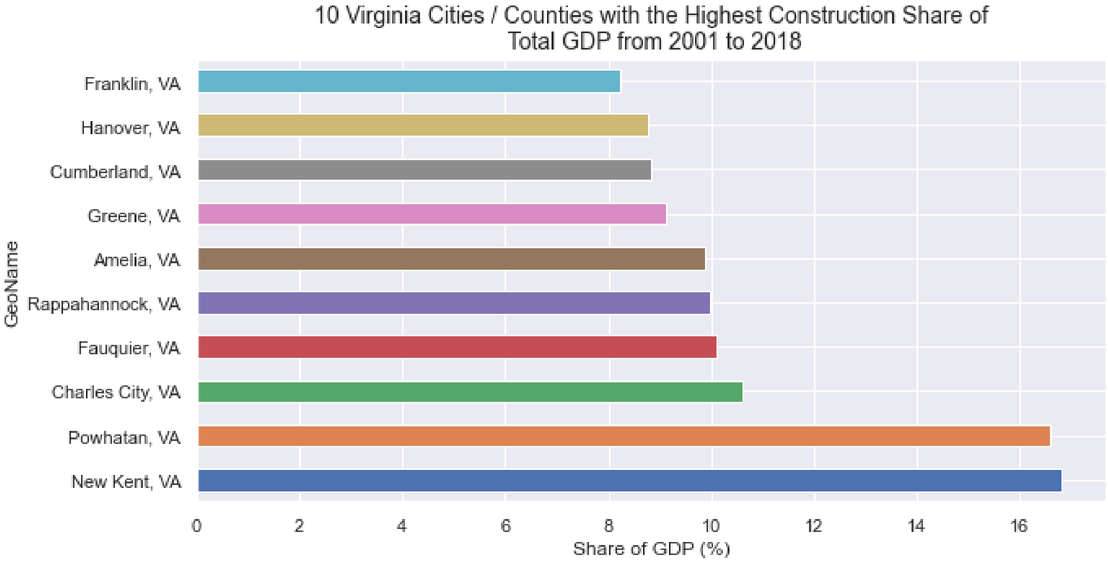
1.8 6C. Evaluating Trends in GDP by Industry: Finding the Most Significant Areas by Industry

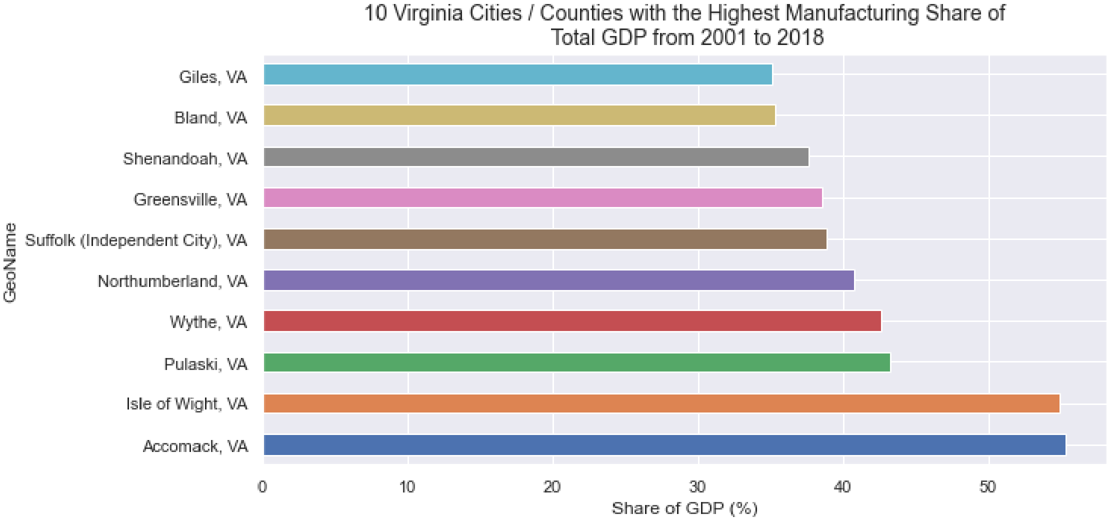
```
[45]: def IndustryPlot(df, x):
          df = df.loc[:, x].sort_values(ascending=False).head(10)
          df.plot(kind='barh', color=sb.color_palette(), sort_columns=True)
          y = str(x)
          plt.title('10 Virginia Cities / Counties with the Highest '+y+' of\n Total␣
       ↪GDP from 2001 to 2018',size=14)
          plt.xlabel('Share of GDP (%)')
          plt.ylabel('GeoName')
          plt.show()
```

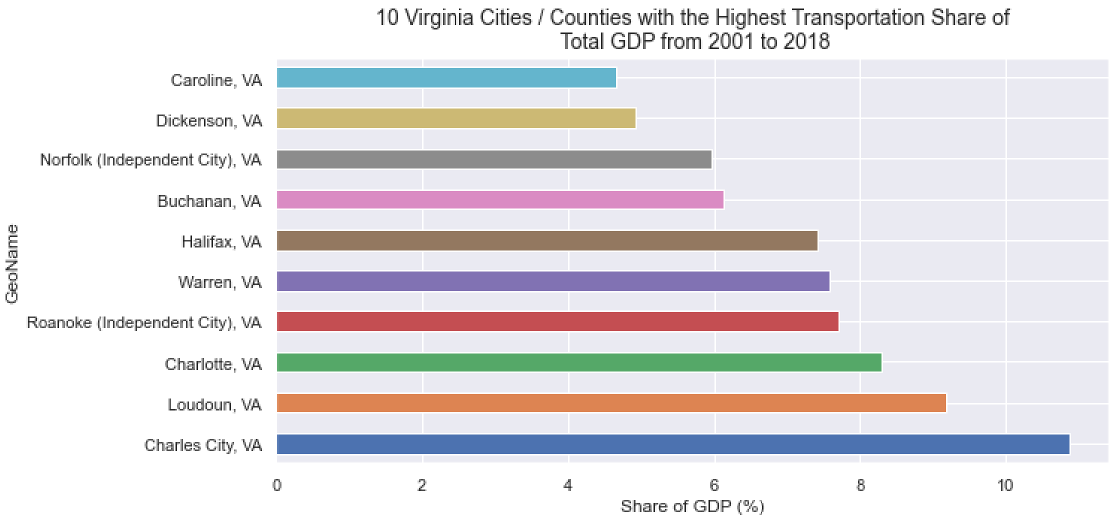
```
[46]: IndustryPlot(gdp,'Utilities Share')
      print()
      IndustryPlot(gdp,'Construction Share')
      print()
      IndustryPlot(gdp,'Manufacturing Share')
      print()
      IndustryPlot(gdp,'Transportation Share')
```

```
print()
IndustryPlot(gdp,'Information Share')
print()
IndustryPlot(gdp,'Finance Share')
print()
IndustryPlot(gdp,'Professional Services Share')
print()
IndustryPlot(gdp,'Education / Health Share')
print()
IndustryPlot(gdp,'Entertainment Share')
print()
IndustryPlot(gdp,'Other Services Share')
print()
IndustryPlot(gdp,'Government Share')
print()
IndustryPlot(gdp,'Natural Resources Share')
print()
IndustryPlot(gdp,'Trade Share')
```

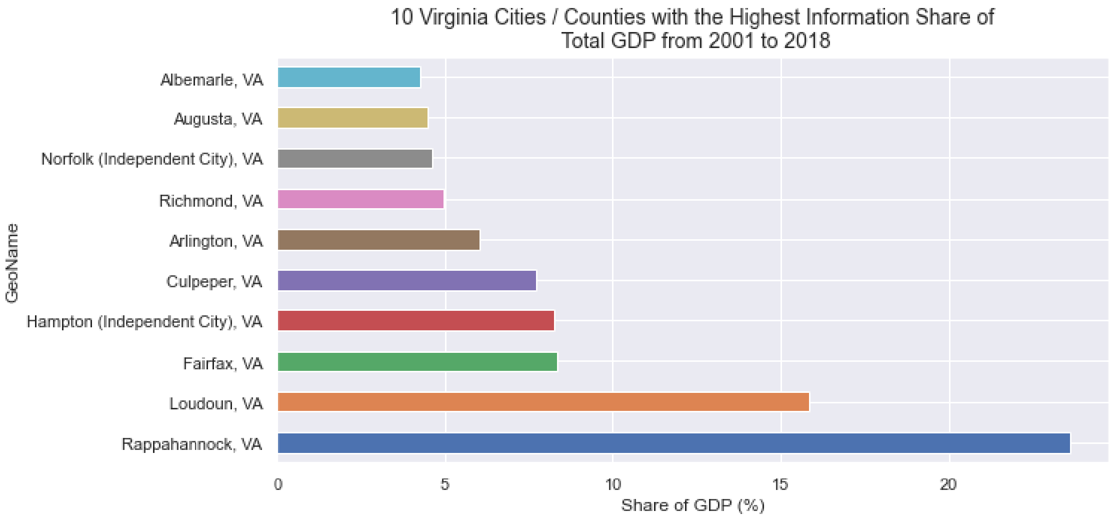



10 Virginia Cities / Counties with the Highest Construction Share of Total GDP from 2001 to 2018
GeoName
Franklin, VA
Hanover, VA
Cumberland, VA
Greene, VA
Amelia, VA
Rappahannock, VA
Fauquier, VA
Charles City, VA
Powhatan, VA
New Kent, VA
0
2
4
6
8
10
12
14
16
Share of GDP (%)

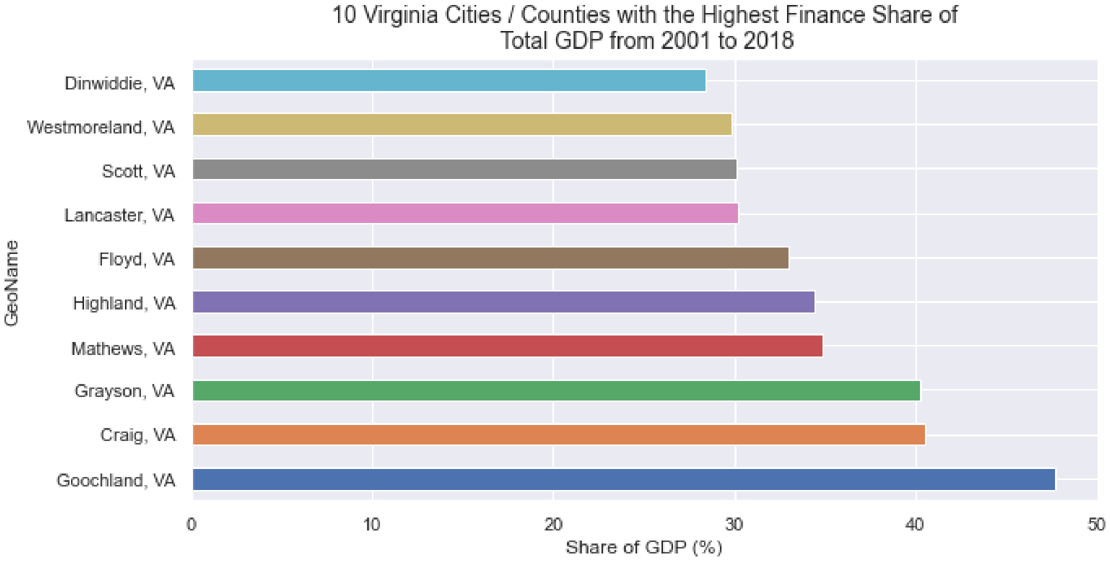

10 Virginia Cities / Counties with the Highest Manufacturing Share of Total GDP from 2001 to 2018
GeoName
Giles, VA
Bland, VA
Shenandoah, VA
Greensville, VA
Suffolk (Independent City), VA
Northumberland, VA
Wythe, VA
Pulaski, VA
Isle of Wight, VA
Accomack, VA
0
10
20
30
40
50
Share of GDP (%)

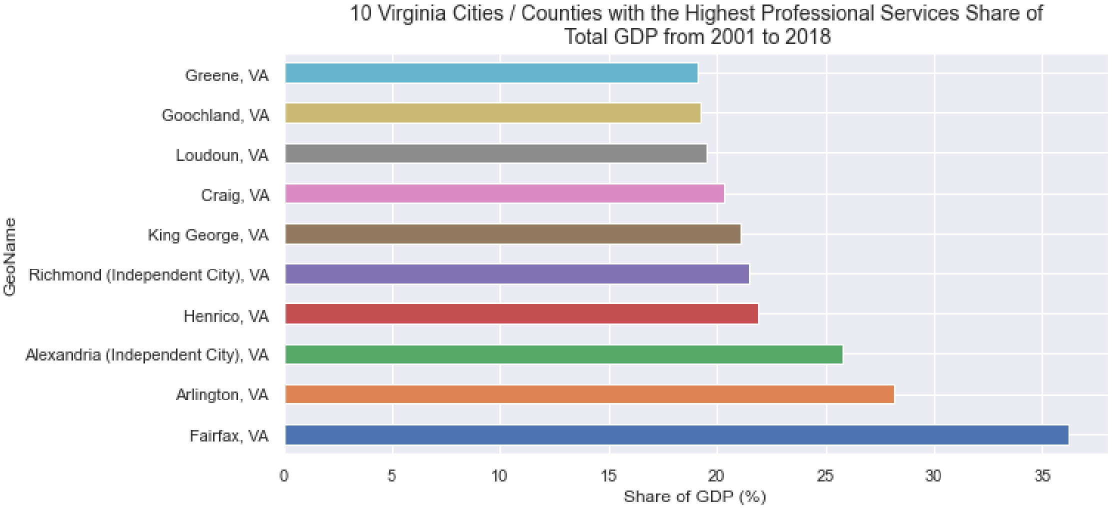


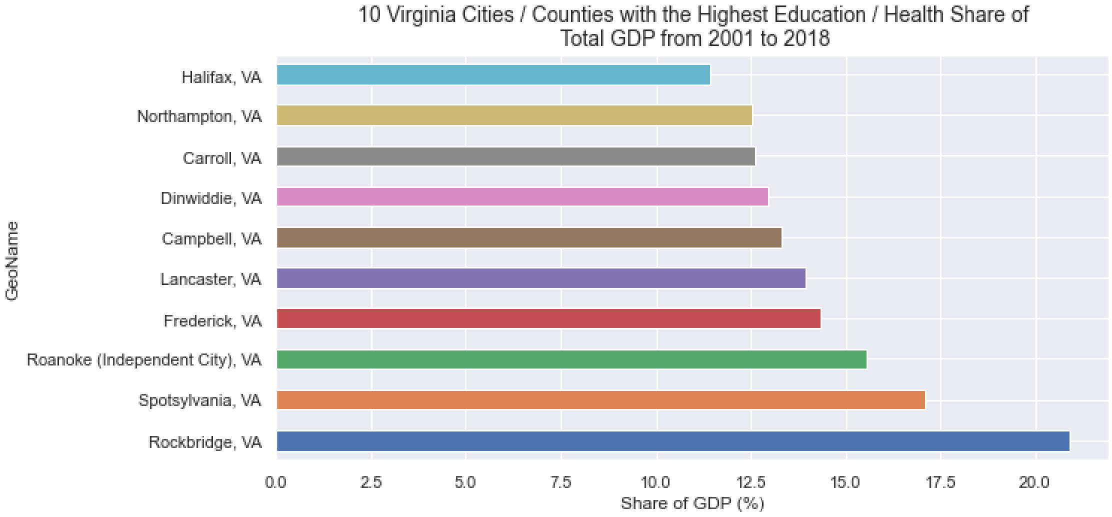
10 Virginia Cities / Counties with the Highest Transportation Share of Total GDP from 2001 to 2018

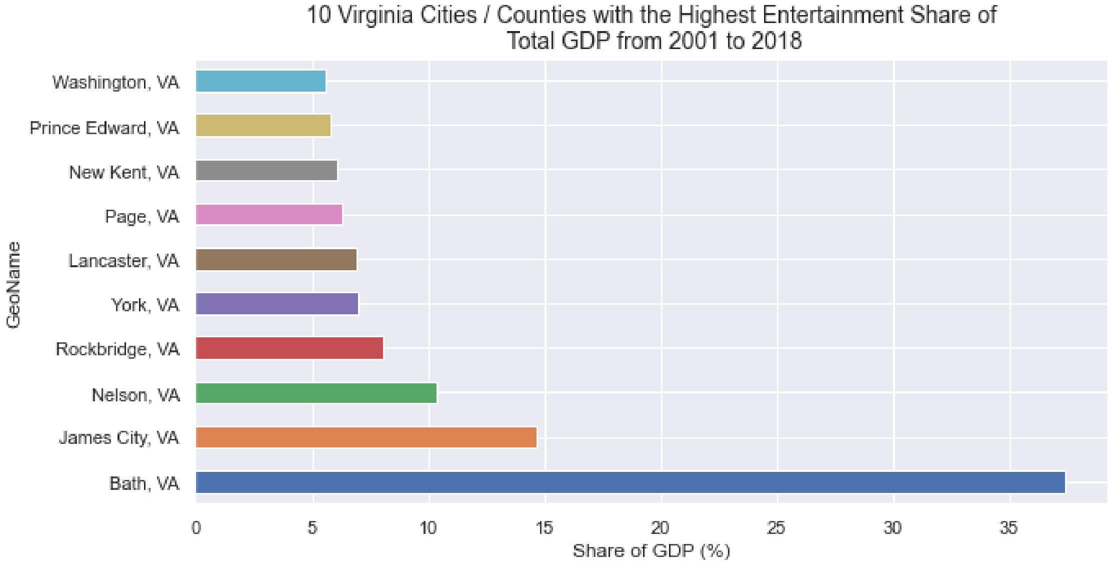


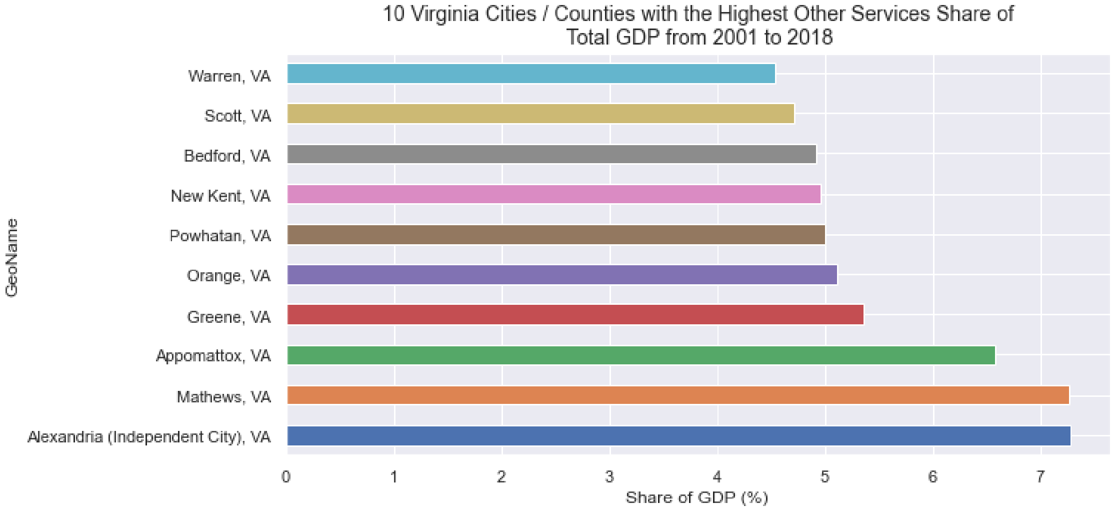
10 Virginia Cities / Counties with the Highest Information Share of Total GDP from 2001 to 2018

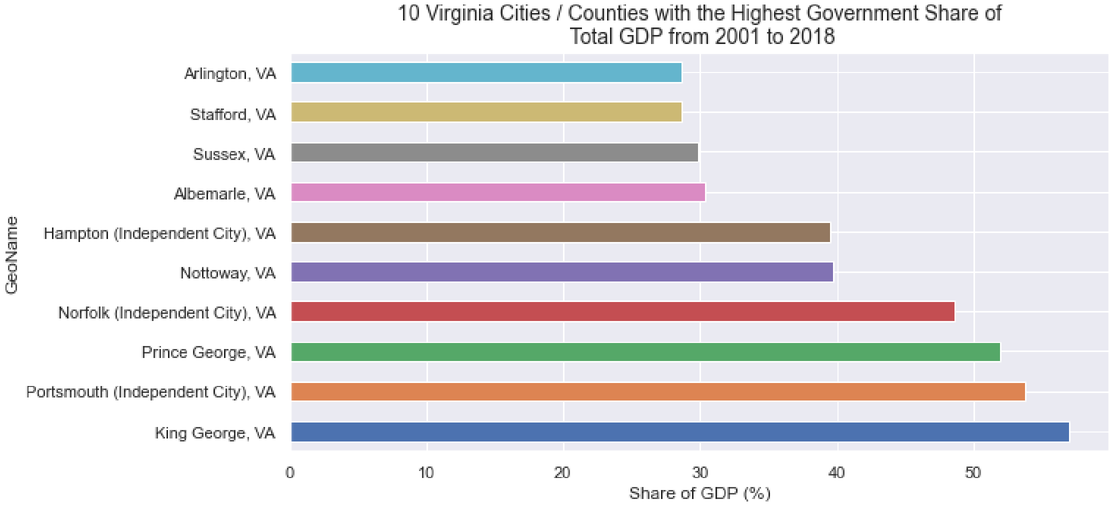

10 Virginia Cities / Counties with the Highest Finance Share of Total GDP from 2001 to 2018
GeoName
Dinwiddie, VA
Westmoreland, VA
Scott, VA
Lancaster, VA
Floyd, VA
Highland, VA
Mathews, VA
Grayson, VA
Craig, VA
Goochland, VA
0
10
20
30
40
50
Share of GDP (%)

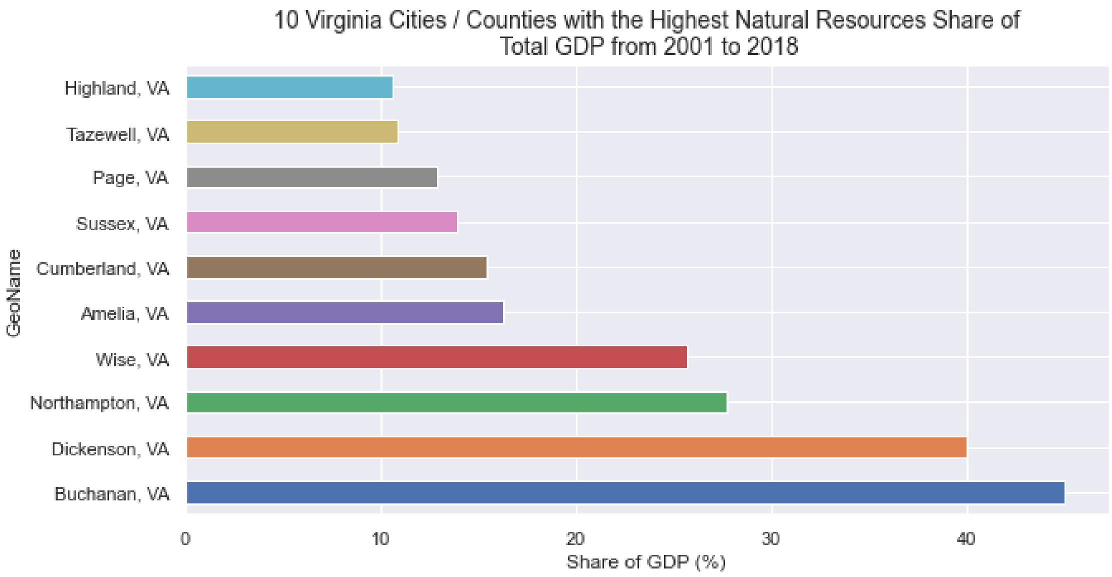

10 Virginia Cities / Counties with the Highest Professional Services Share of Total GDP from 2001 to 2018
GeoName
Greene, VA
Goochland, VA
Loudoun, VA
Craig, VA
King George, VA
Richmond (Independent City), VA
Henrico, VA
Alexandria (Independent City), VA
Arlington, VA
Fairfax, VA
0
5
10
15
20
25
30
35
Share of GDP (%)

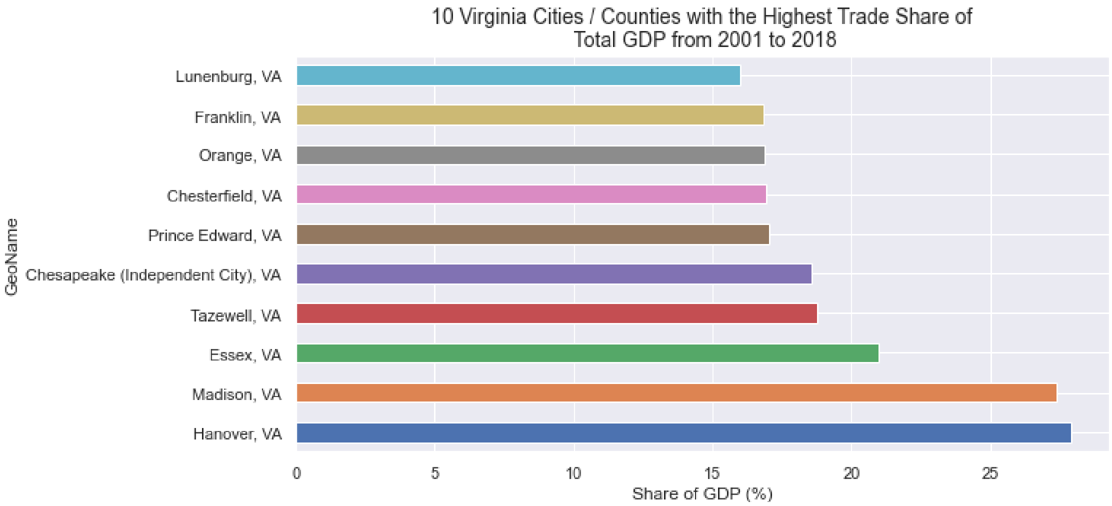

10 Virginia Cities / Counties with the Highest Education / Health Share of Total GDP from 2001 to 2018
GeoName
Halifax, VA
Northampton, VA
Carroll, VA
Dinwiddie, VA
Campbell, VA
Lancaster, VA
Frederick, VA
Roanoke (Independent City), VA
Spotsylvania, VA
Rockbridge, VA
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
Share of GDP (%)


10 Virginia Cities / Counties with the Highest Entertainment Share of Total GDP from 2001 to 2018
GeoName
Washington, VA
Prince Edward, VA
New Kent, VA
Page, VA
Lancaster, VA
York, VA
Rockbridge, VA
Nelson, VA
James City, VA
Bath, VA
0
5
10
15
20
25
30
35
Share of GDP (%)


10 Virginia Cities / Counties with the Highest Other Services Share of Total GDP from 2001 to 2018
GeoName
Warren, VA
Scott, VA
Bedford, VA
New Kent, VA
Powhatan, VA
Orange, VA
Greene, VA
Appomattox, VA
Mathews, VA
Alexandria (Independent City), VA
0
1
2
3
4
5
6
7
Share of GDP (%)


10 Virginia Cities / Counties with the Highest Government Share of Total GDP from 2001 to 2018
GeoName
Arlington, VA
Stafford, VA
Sussex, VA
Albemarle, VA
Hampton (Independent City), VA
Nottoway, VA
Norfolk (Independent City), VA
Prince George, VA
Portsmouth (Independent City), VA
King George, VA
0
10
20
30
40
50
Share of GDP (%)





1.9 6D. Evaluating Trends in GDP by Industry: Isolating Industry Shares Within Areas

[47]:
```
share = gdp.drop('Total GDP', axis=1)
share = share.transpose() #We transpose back to the original shape to preserve␣
↪the industries as the rows.
share = share.iloc[13:]
share = share.rename_axis('Industry Share').reset_index()
share = share.set_index('Industry Share') #We replace our original GeoName␣
↪index with the Industry Share one.
share
```

[47]:

```
GeoName                      Accomack, VA  Albemarle, VA  \
Industry Share
Utilities Share                  0.653709       0.214588
Construction Share               2.004401       4.567087
Manufacturing Share             55.404522       3.320512
Transportation Share             0.344900       0.000000
Information Share                0.621876       4.242969
Finance Share                   10.741535      22.573340
Professional Services Share      5.372014      13.140878
Education / Health Share         1.327896       9.267149
Entertainment Share              2.043264       4.821685
Other Services Share             1.382763       3.235907
Government Share                10.500393      30.430700
Natural Resources Share          5.199363       0.119417
Trade Share                      4.403379       4.065761

GeoName                      Alexandria (Independent City), VA  Alleghany, VA  \
Industry Share
Utilities Share                                       0.105260       6.009467
Construction Share                                    2.819694       5.141157
Manufacturing Share                                   0.271806       5.534495
Transportation Share                                  1.333205       3.875837
Information Share                                     3.891421       0.000000
Finance Share                                        20.985408      27.295272
Professional Services Share                          25.800185       7.691996
Education / Health Share                              4.762756      11.319470
Entertainment Share                                   2.801459       3.288607
Other Services Share                                  7.276707       4.261427
Government Share                                     24.895639      18.421729
Natural Resources Share                               0.000426       0.137763
Trade Share                                           5.056034       7.022774

GeoName                      Amelia, VA  Amherst, VA  Appomattox, VA  \
Industry Share
Utilities Share                0.501935     0.104654        0.705174
Construction Share             9.880948     6.199278        8.229483
Manufacturing Share            7.753961    21.930871        9.186193
Transportation Share           1.255392     3.356941        1.588360
Information Share              0.462740     3.011668        0.506848
Finance Share                 18.220961    21.651868       25.836180
Professional Services Share    8.731538     1.809741        7.646016
Education / Health Share       5.638364     7.667230        3.792058
Entertainment Share            0.928759     2.636212        1.693870
```

```
Other Services Share           3.298369     3.084093        6.573467
Government Share              12.355454    22.731848       19.805778
Natural Resources Share       16.325653     0.928470        3.769286
Trade Share                   14.645928     4.887126       10.667291

GeoName                      Arlington, VA  Augusta, VA   Bath, VA  …  \
Industry Share                                                      …
Utilities Share                   0.282340     0.411340   5.759797  …
Construction Share                1.647837     3.020478   4.071840  …
Manufacturing Share               0.268578    25.437739   1.716395  …
Transportation Share              4.381274     2.150022   0.033663  …
Information Share                 6.009411     4.485117   0.871206  …
Finance Share                    17.158127    24.544360  20.405979  …
Professional Services Share      28.182826     7.517107   8.839087  …
Education / Health Share          4.200271     8.337177   5.506959  …
Entertainment Share               3.656058     3.161404  37.380661  …
Other Services Share              3.490666     3.567050   1.281310  …
Government Share                 28.649230    16.416335  10.187450  …
Natural Resources Share           0.003800     0.194129   1.263811  …
Trade Share                       2.069575     0.757731   2.681840  …

GeoName                      Surry, VA  Sussex, VA  Tazewell, VA  \
Industry Share
Utilities Share              87.218248    1.309395      0.461959
Construction Share            0.975498    2.142077      3.587515
Manufacturing Share           0.782297    3.284122     17.108203
Transportation Share          0.029544    3.774179      0.000000
Information Share             0.004331    0.002780      1.310336
Finance Share                 3.068089   17.831967     20.712240
Professional Services Share   4.095871   10.952672      6.291689
Education / Health Share      0.024121    8.038774      0.000000
Entertainment Share           0.056925    2.823749      3.533446
Other Services Share          0.312452    2.615276      3.593307
Government Share              2.969758   29.849781     13.766425
Natural Resources Share       0.172805   13.959716     10.845560
Trade Share                   0.290088    3.415512     18.789321

GeoName                      Virginia Beach (Independent City), VA  \
Industry Share
Utilities Share                                            0.108188
Construction Share                                         5.309773
Manufacturing Share                                        3.447579
Transportation Share                                       0.000000
Information Share                                          2.704637
Finance Share                                             24.457515
Professional Services Share                               12.160653
Education / Health Share                                   8.224182
```

```
Entertainment Share                                       4.783428
Other Services Share                                      2.200546
Government Share                                         24.285099
Natural Resources Share                                   0.002775
Trade Share                                              12.315628

GeoName                      Warren, VA  Washington, VA  Westmoreland, VA  \
Industry Share
Utilities Share                2.568143        0.453024          0.116046
Construction Share             6.444745        1.003689          4.647435
Manufacturing Share           18.112139       27.959445         19.163156
Transportation Share           7.586176        0.844234          1.075566
Information Share              0.842126        2.569528          0.217049
Finance Share                 19.845273       23.275795         29.835203
Professional Services Share    8.935897       10.519703          7.834401
Education / Health Share       9.836187        9.126596          3.249536
Entertainment Share            4.123292        5.564316          3.928586
Other Services Share           4.531830        3.122941          3.060091
Government Share              12.935130       13.946586         14.429778
Natural Resources Share        0.078543        0.521892          3.764979
Trade Share                    4.160515        1.092258          8.678174

GeoName                       Wise, VA  Wythe, VA   York, VA
Industry Share
Utilities Share               5.425625   0.101189   6.605741
Construction Share            2.771241   2.549199   7.980791
Manufacturing Share           4.445146  42.601804   1.161987
Transportation Share          0.871924   1.711936   0.296146
Information Share             2.909410   1.114088   0.231894
Finance Share                15.732092  14.291899  28.231503
Professional Services Share   6.853696   2.423138  11.635280
Education / Health Share      9.152594   6.729729   4.216849
Entertainment Share           1.419122   4.288242   7.023202
Other Services Share          2.151046   2.006896   3.777345
Government Share             16.503812  11.488328  25.757940
Natural Resources Share      25.710002   1.625003   0.118815
Trade Share                   6.054303   9.068553   2.962510

[13 rows x 105 columns]
```

[48]:

```python
def topfive(geo, total=5):
    df = share.loc[:,geo]
    top = df.sort_values(ascending=False)
    top = top.reset_index().head(total)
    top.index = top.index + 1
    return top
```

[49]:

```
topfive('Fairfax, VA')
```

[49]:

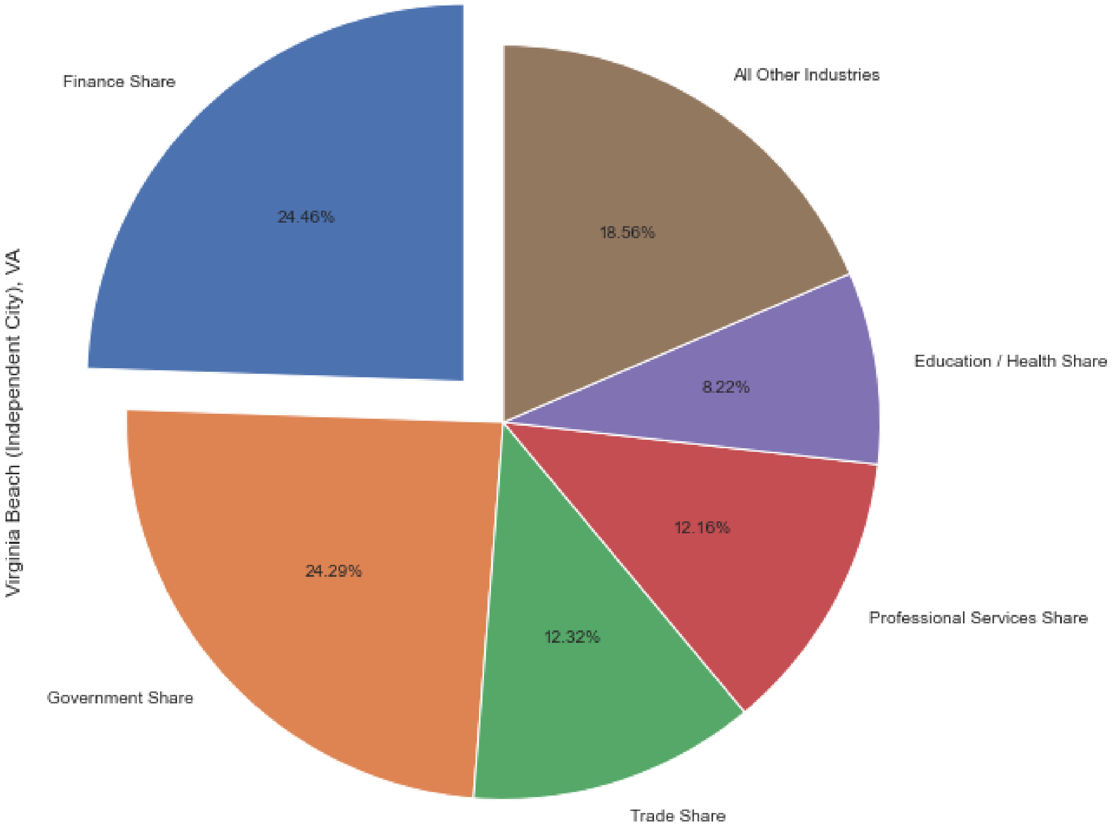
```
                 Industry Share  Fairfax, VA
1  Professional Services Share    36.207336
2                Finance Share    20.553628
3             Government Share    13.905597
4            Information Share     8.328271
5     Education / Health Share     5.689489
```

[50]:

```
def SharePlot(geo):
    df = share[geo]
    top = df.sort_values(ascending=False)
    top = top.reset_index()
    top.index = top.index + 1
    others = top[5:].sum()[1]
    top = top[:5]
    top.loc[10] = ('All Other Industries', others)

    plot2 = top[geo].plot.pie(subplots=True,
                              autopct='%0.2f%%',
                              fontsize=10,
                              figsize=(10,10),
                              legend=False,
                              labels=top['Industry Share'],
                              shadow=False,
                              explode=(0.15,0,0,0,0,0), #We explode the largest␣
 ↪industry share here.
                              startangle=90)
```

[51]:

```
SharePlot('Virginia Beach (Independent City), VA')
```



1.10 7. Predictions

At first glance, we can predict the areas located in the Northern Virginia region will continue to see more people move within their geographic limits. When considering their trends, other areas further from Washington, DC, such as Spotsylvania and Stafford Counties, could also witness such shifts.

In addition, while accounting for the impact of globalization and interstate commerce, we can expect that the share of GDP toward industries such as information, finance, and professional services will continue to grow in counties and cities throughout the state. The rate of such growth, however, may be slower in less urbanized counties and cities. Given such shifts, personal income may rise as more jobs within these aforementioned industries develop.

However, we should also consider that, as a result of increased demand for these types of jobs, if the rate at which an area's population grows exceeds that of its personal income, then the relative change in per capita income may be muted at best. In other words, it is possible for an area to augment its personal income significantly over the next couple of years, but not its per capita income if enough people move there within that time span.

1.11 8. Conclusions

As can be seen, the role of geography in impacting the predominant economic sectors of Virginia's counties and cities from 2001 to 2018 should not be minimized. For example, we can deduce that a plurality of Bath County's economy, which focused primarily on its arts and entertainment sector, may have been buoyed by its proximity to West Virginia and the Appalachian Mountains, making it a popular spot for tourism despite its relatively small population. Similarly, further to the south of the state, Buchanan County's geography can likewise serve as an explanation as to why a greater share of its economy was based on natural resources, including operations related to mining and quarrying.

From the data, it appears that a highly diversified economy is more prudent toward increasing personal and per capita income over time, as well as encouraging more people to move toward an area. Specialization is instrumental in bringing a wider array of skills toward boosting growth, and potentially allowing collaboration between different industries. It is an extension to the accelerating shift toward white-collar occupations throughout the economy today, at both the state and national level. In addition, specialization may explain why some counties and cities reported higher total GDPs from 2001 to 2018 without necessarily allocating a significantly large share toward one industry, be it a plurality or majority. As economic diversification in an area accelerates, the rate of urbanization likewise grows, which in turn encourages more people to move and find work there.

Earlier in our project, we observed that the areas witnessing the greatest growth in personal and per capita income, as well as population, in absolute terms from 2001 to 2018 tended to be further up north. This makes sense considering the rapidly expanding influence of the Washington, DC metropolitan area on the US economy. Fairfax and Loudoun Counties especially reported considerable shifts in the aforementioned variables. When observing these variables from a relative perspective though, the impact was more muted, particularly when considering how population growth can outpace that of personal and per capita income, even with significant economic expansion. In relative terms, Loudoun County is an intriguing case since its population more than doubled from 2001 to 2018, and it outperformed other areas in its rate of growth in personal, but less so per capita, income.

When comparing GDPs by industry, it is evident at first glance that areas with larger overall economies, especially Fairfax County, often contributed more to an industry. However, this not imply a direct correlation between total GDP and industry share. In fact, in just three sectors (utilities, manufacturing, and government) did a number of areas report a share of 50% or more. According to most other industries' numbers, these did not maintain a disproportionate share, indicating that most areas exhibited relatively diversified economies from 2001 to 2018. This is also apparent when analyzing the industry trends within each individual area.

This project was another terrific opportunity to apply the techniques of data mining toward extracting raw pieces from the Bureau of Economic Analysis with the help of Python. As mentioned before, any references for this project are listed below.

1.12 References

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